Conservation Planning in Central Texas

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Dedication

To Crescent and Simon

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Abstract

Conservation Planning in Central Texas

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Biodiversity and ecological functionality are being lost rapidly due to human transformation of the environment around the planet. Lands dedicated to conservation of biodiversity and ecological functionality play a key role in mitigating and reversing these losses. This study looks at how conservation planning practices can be integrated into an urban-rural area with numerous conservation needs, heterogeneous environments, and rapidly expanding human populations. The study area consists of the five counties in Central Texas surrounding the City of Austin that are being evaluated for land use by the Envision Central Texas project.

Conservation tools used are: 1) environmental space graphs and 2) systematic conservation planning. Environmental space graphs are a straightforward, qualitative visualization tool to analyze the relationships of environmental variables, biodiversity records, existing open space, and proposed conservation lands. Systematic conservation planning used complementarity, .a step-wise process, to select prioritization areas. Selection was based on the occurrence of conservation elements in the following categories: species, species assemblages, topography, soils, geology, weather, critical water quality areas, Edwards Aquifer zones, watersheds, and vulnerability. Forty prioritization runs, each varying the importance of different conservation elements, showed a spectrum of conservation scenarios for Central Texas.

Prioritization results were evaluated based on their representation of biodiversity and environmental variables, the total size of the prioritized areas, feasibility, the use of lexical order in the selection process, and irreplaceability—the repeated occurrence of an area in multiple prioritizations. The actual process of systematic conservation planning was evaluated for its usability within the study area and with available data types.

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CHAPTER 1: INTRODUCTION

THE GLOBAL PROBLEM OF LAND TRANSFORMATION

It is a special time in natural history. Human's tenure on this planet, excluding the past few thousand years, has been marked by a close relationship to nature that included direct correlations between natural phenomena and everyday life. While much of the human population still lives under these circumstances there is a significant component of the global population that has the ability to massively alter and transform the environment to suite its needs. This relatively new ability to indelibly shape the landscape is resulting in huge changes in ecological processes on a global scale. Some examples: Land is being altered by humans at a global rate of 1% per year (Balmford et al. 2002); Every day humans use the same amount of energy it takes the planet 10,000 days to accumulate (Hawken 1993); And, with only a small percentage of existing species documented, the current global rate of extinction is 100 to 1,000 times greater than pre-human levels (Raven and Wilson 1992; Chapin et al. 1997). These environmental alterations are creating unstable natural systems ranging from global warming to ecological failure at the local level. Lands dedicated to the conservation of biodiversity and ecological functionality play a key role to solving these issues. This study looks at how conservation planning in Central Texas can be integrated into an urban-rural area with a globally significant biota and a rapidly expanding human population.

CONSERVATION AS PART OF THE SOLUTION

Human societies are dependent on the environments that surround them. Four decades after Rachel Carlson published *Silent Spring* and six decades after Aldo Leopold published *A Sand County Almanac*, there is still only partial recognition of societal impact and dependence on the environment. This recognition has manifested in a number of programs, organizations, and studies dedicated to increasing conservation lands and understanding their benefits.

Studies have shown that the conservation of natural systems is a cost effective means to meet societal needs for ecological functions. A global assessment of the value of all ecological functions that are beneficial to society, estimated the global value at $33 trillion U.S. dollars per year—twice the global GNP (Costanza et al. 1997). This estimate is based on 17 types of ecosystem services: gas regulation, climate regulation, disturbance regulation, water regulation, water supply, erosion control and sediment retention, soil formation, nutrient cycling, waste treatment, pollination, biological control, refugia, food production, raw materials, genetic resources, recreation, and cultural (Costanza et al. 1997). Most parameters are directly associated with lands for the conservation of biodiversity and ecological functionality.

At the federal level in the United States, conservation is mandate through law under particular circumstances of environmental degradation or potential of extinction. Two of the most powerful forces working for conservation are the Endangered Species Act (1972) and the Clean Water Act (1977). These laws have made sustaining a functioning environment and biodiversity a societal concern. The result in some cases has been an increase in water quality, the recovery of select species, and an increase in land set aside for conservation.

At the local level a number of municipalities are finding that conservation makes both ecological and economic sense. In the early 1990s New York City was facing a substantial increase in its water treatment costs due to a proposed purification plant to deal with the effects of development occurring in the source watershed for the city's drinking water. The projected costs ranged from four to eight billion dollars with annual operating expenses of 250 to 300 million dollars (Appleton 2002; ESA 2000). Rather than constructing the facility, New York City began a watershed protection plan that cost 660 million dollars in land acquisition, easements, and water quality improvements. It accomplished the same goals as the treatment plant at a fraction of the cost (Appleton 2002; ESA 2000).

The same issues rings true within the study that is centered around Austin, TX and includes Bastrop, Caldwell, Hays, Travis and Williamson Counties. The City of Austin expects to spend over $17,000 per acre in some watersheds over the next 40 years to partially mitigate water quality, flooding, and erosion problems (COA 2005). These substantial costs are the result of poor land use decisions and a disregard for ecological services. The costs of these decisions are placed on the long-term tax burden and go unrecognized as an avoidable cost. The same type of decisions and poor development are occurring along SH-130, a new highway that will become one of the most highly used thoroughfares in the study area. In its path are Gilliland Creek and Wilbarger Creek watersheds. These watersheds will be drastically affected by the construction and ensuing development surrounding SH-130. The future costs of status quo development in these two watersheds, looking only at watershed costs per acre from the City of Austin, are so great that land acquisition of select parcels now would result in long-term savings to taxpayers (Ogren 2008).

Beyond direct ecological and economic benefits, open space serves as a planning tool that consolidates infrastructure and creates higher land values by serving as a framework and bounds for urbanization. Parks and open space lands have an overwhelmingly positive impact on land values in their vicinity that leads to higher tax revenues (Crompton 2001). In addition, the lack of any measures to consolidate infrastructure, such as a network of open spaces, results in sprawling residential development with more infrastructure, a larger footprint, more resource needs, and a higher long-term tax burden. A Cost of Community Services study in Hays County based on 1997- 1998 data showed that residential development required $1.25 for every dollar paid in taxes while farming needed $0.33 (AFT 2002). This evidence points to the need for communities to create comprehensive conservation plans that lead to better land use decisions.

CONSERVATION PLANNING TECHNIQUES

Conservation removes threats of destruction or impairment from biodiversity and ecological functionality. Biodiversity can be thought of as the variety of living entities in an area and can be measured at various levels including the species and groups of species. Ecological functions are the basic processes occurring in our environment including nutrient, energy, and hydrologic cycles. A primary conservation tool is the acquisition of land, in easement or ownership, for the protection of biodiversity and ecological function.

Conservation efforts have historically been reactive processes (Margules 1989; Pressey et al. 1993). Lands in conservation have often resulted from socio-economic issues, such as lack of commercial or agricultural use, rather than decisions based on the land's biological or ecological value. The outcome has often been a set of lands that do not efficiently, if at all, protect the most vital conservation elements. To address these inefficiencies, a process known as systematic conservation planning was developed that evaluates areas based on quantifiable goals to determine conservation priorities (Margules, Pressey, and Williams 2002; Pressey et al. 2000).

Key advantages to systematic conservation planning include clear goals, a transparent process, and the ability to quantify success or failure (Margules and Pressey 2000). The process consists of the following steps:

1) Compile data on natural features,
2) Identify conservation goals,
3) Evaluate the extent to which existing conservation lands meet those goals,
4) Select additional areas for conservation,
5) Implement conservation of selected areas, and
6) Manage conservation areas to maintain conservation goals (Margules and Pressey 2000; Williams and Araujo 2002; Williams, Margules, and Hilbert 2002).

This study will focus on compilation of data, identification of goals, evaluation of existing conservation lands, and prioritization of sites for Central Texas. The selection of areas is completed by adding one area at a time through a step-wise process that selects the area with the most conservation elements that have not met their desired levels in the areas already prioritized. This concept is known as complementarity because the conservation elements contained in the newly selected area complement those already found in the previously prioritized sites or the existing preserve network (Margules 1988). Once a conservation element meets its desired levels, its target, it is no longer considered when choosing areas. When all conservation elements meet their targets, the prioritization process is complete.

Systematic planning procedures are becoming the norm for conservation organizations and are replacing single decision processes (Pressey and Taffs 2001; Noss et al. 2002). Projects using systematic conservation planning processes have been used around the world and are in various stages of implementation including: the Cape Action for People and the Environment in South Africa, the National Study of Biodiversity and Planning for Papua New Guinea, and forest protection in New South Wales, Australia (Cowling et al. 2003; Williams 1998; Margules and Pressey 2000).

CENTRAL TEXAS

This study looks at how conservation planning can be integrated into the urban-rural area in Central Texas surrounding Austin, TX. The study area is the same area considered for future planning by the Envision Central Texas project *(http://www.envisioncentraltexas.org/)* and includes the five counties of Bastrop, Caldwell, Hays, Travis, and Williamson.

The area is significant ecologically and is considered one of the areas most in need of conservation in Texas (Diamond, True, and He 1997; Bezanson 2000). The area possesses different substrates, topographic change, the Balcones Escarpment, the Edwards Aquifer, and Blackland Prairie. These components, along with the geographic location of the study area, result in a biotic transition zone that is defined by shifts in species composition within the study area (Turner 1959; Gould, Hoffman, and Rechenthin 1960; MacRoberts and MacRoberts 2003). The area is significant for migrating birds, vascular plants, karst fauna, and spring fauna (Johnston 1997; Diamond, True, and He 1997; BCCP 2004).

These factors and a willing populous have resulted in conservation programs that currently cover 4.1% of the study in open space. Open space is any green area dedicated to recreation, conservation, or cultural preservation. Example conservation programs include water quality programs over the Edwards Aquifer and biodiversity conservation in the Balcones Canyonlands. Protection of water quality over the Edwards Aquifer has resulted in over 141.6 km^2 (35,000 acres) of conserved land. Habitat protection for endangered species, including the golden-cheeked warbler and the black-capped vireo, in the Balcones Canyonlands has resulted in over 113 km² (28,000) acres in conservation lands.

Even with these programs, there are still substantial threats to plant and animal habitat, as well as ecological processes. While existing programs have met many conservation needs, there has not been a comprehensive conservation plan for the area. This is partly due to weak regional planning authority in Texas, lack of data, and lack of access to appropriate methods. With the continued threats to natural systems posed by increased population growth, this study meets the critical need for regional conservation planning.

The areas population is projected to increase 70 to 210% over 2006 level of 1,519,220 by 2040 (TWDB 2002; TSDC 2006). The Envision Central Texas Project proactively created scenarios to accommodate this future population (ECT 2004). With the input of approximately 13,000 citizens through surveys and workshops, the project has established preferred scenarios and critical issues for the future. Preferred scenarios call for denser development around existing urban areas, thereby decreasing infrastructure costs, creating more cohesive communities, and leaving more land for biodiversity and ecological services (ECT 2004).

THIS STUDY: CONSERVATION PLANNING IN CENTRAL TEXAS

This study creates understandable and measurable information that can feed into regional planning processes such as the Envision Central Texas Project. In 2004 Envision Central Texas proposed a vision with high levels of citizen input to guide regional planning in the study area. Critical to the realization of this vision is an equally complex understanding and vision for the natural environment and conservation priorities within the five counties evaluated by both projects.

This study asks what needs to be conserved, how can it be quantified, how can it be evaluated, and how can areas be prioritized. Systematic conservation planning, with the use of environmental space graphs, answers these questions. The prioritization of areas was based on the following categories of conservation elements:

1) rare and threatened species,
2) species assemblages,

3) climatic classes,
4) topography classes,
5) geologic types,
6) soil types,
7) critical water quality areas including floodplains,
8) Edwards Aquifer zones,
9) watersheds, and
10) vulnerability zones.

These elements were evaluated using the ResNet software program *(http://uts.cc.utexas.edu/~consbio/Cons/Labframeset.html)* to determine priority areas in forty different scenarios, each scenario varying the importance of different conservation elements.

Data used for the evaluation came from multiple sources, including: local municipalities and planning organizations, Texas Parks and Wildlife Department, the Nature Conservancy, U.S. Fish and Wildlife Service, U.S. Geologic Service, Texas Natural Information Service, Capital Area Planning Organization, and Worldclim. The evaluation primarily used 0.25 km^2 (61.8 acres) evaluation units in a grid system. Prioritization runs were initialized with open space lands classified as preserves or state parks—an area of 273.2 km^2 (67,509 acres).

Many existing parks and preserves were motivated by the protection of watersheds including areas over the Edward's Aquifer and local riparian green belts. In addition many of the preserve and state lands possess water features. Because water plays such a key role in the acquisition of open space in the study area, and will continue to do so, it was given special attention in the planning process. To acknowledge these issues in the conservation planning process, three datasets were used: critical water quality areas including floodplains, the Edwards Aquifer (divide into four zones), and watersheds.

Prioritizations incorporated vulnerability with variables associated with the fragmentation of the landscape and proximity to existing developed areas. Vulnerability variables preferred conservation adjacent to municipalities where the likelihood of habitat destruction is high, outside of city centers where the likelihood of conservation is low, and in areas outsides the desired growth zones put forth by Envision Central Texas Scenarios.

Environmental space graphs show the relationship of environmental variables to existing open space, biodiversity data, and prioritized areas(Austin, Nicholls, and Margules 1990; Austin and Heyligers 1989). This qualitative tool allowed for a general assessment and understanding of where conservation is effective and where more conservation lands are needed. This same process, used with select prioritization results, showed how varying the target levels for conservation elements altered the solution sets representation of environmental space and biodiversity.

Resulting prioritized areas were evaluated based on their total area, representation of biodiversity and environmental variables, use of lexical order, and feasibility. The study points to potential conservation scenarios, and showcases areas that are of high conservation value through an irreplaceability measure. These findings along with supporting data should be used to create actionable steps towards acquisition of conservation lands. The cumulative result of this and similar studies is the movement towards integrated planning and management practices that better utilize resources to protect, preserve, and utilize biodiversity and ecological function.

CHAPTER 2: REVIEW OF SYSTEMATIC CONSERVATION PLANNING AND ASSOCIATED DISCIPLINES

One major goal of conservation is to separate biodiversity and ecological functions from threats (Margules and Pressey 2000). Systematic conservation planning seeks to accomplish this efficiently through quantifiable goals and a step-wise process. The result is a set of priority areas that include the desired conservation elements in the smallest area possible (Williams 1998).

There are two fundamental premises in systematic conservation planning. First each element or variable is given a specific target of representation within the conservation network—generally measured as an area of occurrence. Second, areas for prioritization are chosen in a step-wise process called complementarity that adds areas one-by-one based on which area adds the most to unmet conservation goals. Conservation goals, called targets, are a metric to quantify the conservation planning process and evaluate complementarity (Pressey and Cowling 2001; Sarkar et al. 2004). An example of a target could be conserving 15 % of a particular species' known habitat. Using a step-wise process to determine conservation priorities is today considered a critical part of creating an efficient conservation plan (Margules and Pressey 2000).

COMPONENTS OF SYSTEMATIC CONSERVATION PLANNING

From initial research to implementation, conservation planning integrates multiple disciplines. This study focuses on components of the process that analyze existing data and prioritize areas for protection using a systematic conservation planning methodology. Components of the process covered in this study are: 1) Compilation and assessment of data; 2) Identifying goals and targets; and 3) Prioritization of areas for conservation (Margules and Pressey 2000). This process is ideally a part of a stakeholder process that allows the results to react to input and newly found information. In the future, this study can be integrated into such a process.

COMPILATION AND ASSESSMENT OF DATA

Data can come from the field, general environmental variables, modeled habitat data, surveys conducted specifically for the planning process, expert opinion, and stakeholders. The best conservation plans result from processes using a combination of data representing species, species assemblages, and environmental attributes (Pressey 1993; Margules and Pressey 2000). Ideally, a comprehensive conservation data set will exist for the study area or there is enough time and resources to complete needed surveys (Nicholls and Margules 1992; Margules et al. 1994; Margules, Nicholls, and Austin 1987; Austin and Heyligers 1989; Austin, Cunningham, and Fleming 1984). This is, however, rarely the case and decisions with existing data are usually needed in a timely manner.

Available data often come from opportunistic surveys undertaken to look at a particular species or investigate a specific area and are rarely biologically or spatially comprehensive (Margules et al. 1994; Ferrier 2002). For instance, herbarium and museum records are generally biased towards more accessible areas, and only record the presence of a species. In addition, these data are usually taken at a scale that is not conducive to conservation planning with location information having a high degree of potential error.

It is imperative to explicitly state what data are being used, how they are being used, and how they are being standardized over the study area (Margules and Pressey 2000). Evaluation of the data can include evaluating for nomenclature and verifications of locations (Williams 2002). If data are not used correctly it will lead to inaccurate results, or worse, poor use of finite conservation resources.

IDENTIFYING GOALS AND TARGETS

Conservation Elements

Conservation elements are the biodiversity or environmental variables that are used to prioritize areas. Much of the systematic conservation planning literature refers to conservation elements as surrogates. This term expands the meaning of conservation element from being an individual location of a specific species or environmental variable to a broader representation of biodiversity or ecological function (Margules, Pressey, and Williams 2002). Surrogates are used in conservation planning because there is generally not an existing comprehensive dataset and there is not enough time or resources to produce one. They are broken into two categories for this study: 1) true surrogates are known conservation elements such as an endangered species, a particular type of bird, or an assemblage of species and 2) environmental surrogates are abiotic characteristics of the landscape (Margules, Pressey, and Williams 2002). Working with both true and environmental surrogates results in the best representation of biodiversity and ecological processes as it makes the most of available data and allows both form and function to be incorporated into the conservation process (Margules, Pressey, and Williams 2002; Oliver et al. 2004; Margules and Pressey 2000).

The most common true surrogates are species, either as populations or individuals. Species are an extremely powerful tool for conservation due to their ability to be identified and quantified and the protection afforded them by the Endangered Species Act.

Species assemblages are groups of species that have an evolutionary relationship (Faith and Walker 1996). Assemblages generally contain a number of key characteristic species or are characterized by unique interactions between species (Margules, Pressey, and Williams 2002). Defining assemblages theoretically and in the field is more difficult than identifying a species as there are more variables involved including the correct identification of a number of species in the right ratios and identifying the extent to which they occur. These difficulties make species the preferred true surrogate for conservation planning.

Environmental variables are often used to identify species habitat (Margules, Pressey, and Williams 2002). Biodiversity patterns are based on abiotic factors including: terrain, climate, and substrate (Williams et al. 2002). The biological significance, relative accessibility, and continuity throughout many study areas make environmental variables extremely appealing for conservation planning (Williams et al. 2002). The specific environmental variables used differ from study to study or area to area due to particular circumstances of the planning process and the environment (Margules et al. 1994).

Ideally environmental variables would be chosen for their known ability to predict actual conservation elements such as a species (Simberloff 1998). This information is unknown for most conservation elements making it an unfeasible goal especially when considering the multiple environmental factors influencing the occurrences of multiple species (Simberloff 1998). If the purpose of environmental variables in conservation plans is broadened to ensure the representation of those variables that coincide with true surrogates then it is a feasible and measurable goal (Garson, Aggarwal, and Sarkar 2002). In addition, striving for environmental diversity in conservation lands, especially where species or species assemblage data is inadequate, is a reasonable and justifiable conservation goal (Faith 2003). Environmental variables have been used in a number of ways including: categorical data, such as climate and soil variables, spatial surrogates for ecological processes such as stream buffers, and even as a measure of environmental variability (Sarkar et al. 2005; Pressey et al. 1993; Faith and Walker 1996).

Evaluation Units

Evaluation units allow for the comparison of areas by breaking the study area into identifiable units. Each unit has quantifiable occurrences for each of the conservation elements. A number of shapes and sizes are used as evaluation units including land parcels, watersheds, grid cells, and hexagons (Whittaker et al. 2005; Margules and Pressey 2000). Evaluation units must allow for justifiable comparisons between one another, must be computationally feasible, and must have a reasonable relationship to implementable conservation areas (Williams, Margules, and Hilbert 2002).

The most commonly used shapes are square grid cells. They are easy to set up and are computationally straightforward. There is justification for trying other units such as watersheds. Other planning processes have used hexagons, land parcels, and ecological divisions of the landscape (Whittaker et al. 2005).

In addition to the shape, the size of an evaluation unit can play a significant role in the outcome of conservation planning processes and there can be a number of disadvantages to evaluation units that are too small or too large for a particular study. As one of the major criteria for measuring the success of systematic conservation planning is the area it takes to conserve conservation elements, it follows that using smaller evaluation units will lead to smaller solution sets. Planners must be wary of false efficiencies created by using smaller cells. Taken to an extreme, evaluation units could be reduced to nearly a point. The resulting solution set would suffer from a number of inadequacies. It would have no management or habitat context, it would belie the fact that the point data are an arbitrary representation of a conservation element that has spatial measurement as well as error, the solution set would lack landscape continuity, and the principles of complementarity would rarely come into play as there would be little overlap of conservation elements.

Taken to the other extreme, the use of extremely large units will make the planning process ineffectual. Evaluation units too large for the scale of the study will create results that are unrealistic with available resources and are not in proportion to conservation element occurrences.

Other considerations must include the computational complexity of particular evaluation units. The processes used to extract spatial data from irregular shapes increases substantially as compared to more regular shapes. In addition, the time to evaluate data increases significantly with an increase in the number of evaluation units.

Setting Targets

Target setting is a critical component of conservation planning as targets allow for measurable results. Targets can be measured by number of populations, number of individuals, percent of habitat, or probability of occurrence (Pressey and Cowling 2001; Sarkar et al. 2004). In this study targets are a percentage of a conservation element's area of occurrence. Ideally, targets have an evolutionary and ecological justification that allow for the long-term viability of the conservation element (Caughley 1994). Unfortunately that type of data is usually unavailable and targets are determined through a subjective balance of ecological knowledge and available resources. That said, a number of governmental agencies and other organizations have created targets for conservation. Some example targets include: Canadian Natural Resource Department's goal of conserving 12% of each ecosystem within Canada, Australia's goal of conserving 15% of each Australian forest type, and Conservation International's goal of conserving 10% of the worlds biota (Sarakinos et al. 2001).

Targets for rare or endangered species are justifiably high because of precedence through law, existing conservation plans, and social concern about extinction. Some plans have had target levels as high as 100% for areas of known endangered species habitat (Noss et al. 2002; Sarakinos et al. 2001). Target levels for more common species, environmental variables, and other conservation elements are generally set lower and must be determined on a case-by-case basis. In most conservation plans, targets will be set to meet the observed ecological needs, balanced by the available resources for conservation (Pressey and Cowling 2001). In the planning processes, target levels can be varied to demonstrate the range of potential outcomes.

Most studies use presence data denoted with a 1 or absence with a 0 for each evaluation unit. For example, if a study uses 0.25 km^2 cells and the target for a particular species is 1 km^2, that species needs to occur in four grid cells in the prioritized areas. In this case, just the occurrence, whether it occurs over the entire grid cell or just a corner, is treated the same.

Probabilistic data have been used to make target setting more precise. Data can be treated as a probability within the study areas by equating the occupied percentage of an evaluation unit as the expectation of finding that conservation element in that area (Sarkar and Margules 2002; Sarkar et al. 2004). For instance, a geologic layer that is found on half of the area of a grid cell would have a value of 0.5, representing half of the whole. This refinement of targets is thought to be a further step towards making conservation planning a quantifiable representation of the actual environment.

Initialization Areas

Existing open space areas already contain some of the conservation elements sought in conservation plans. To access this representation, open space areas are compared against known data sets to determine what conservation elements are already being conserved in open space. The overall targets of each conservation element are then adjusted to reflect this existing representation. The types of open space considered in this prioritization will vary from area to area. A conservative approach is to only include areas designated for preservation of biodiversity or ecological processes.

PRIORITIZATION OF AREAS FOR CONSERVATION

Complementarity is the term used for the step-wise process of choosing areas for conservation (Kirkpatrick 1983; Margules 1988; Nicholls and Margules 1992). The process chooses the next area for prioritization based on which area "complements" the areas already prioritized—the area chosen is the one that has the most conservation elements that are currently underrepresented. This process results in less area needed to represent more conservation elements and thereby makes the conservation planning process more efficient (Williams 1996).

Complementarity is sometimes confused with richness. Species richness is a direct measure of the amount of biodiversity in a given area. It is a ratio of the number of species per area. Complementarity compares the types of conservation elements contained in different areas. It evaluates all areas and adds the evaluation unit containing the most underrepresented conservation elements to the prioritized areas. Once a conservation element meets its target level, it is no longer considered when evaluating further areas (Margules 1988).

The concept of complementarity is explained in Figure 2.1 with species a through g and target levels of one occurrence for each species. Area A is conserved first as it holds the most rare species. The next area chosen using complementarity is D. The two species in D complement the existing conservation elements found in A and allow all targets to be met. If species richness were used instead of complementarity, B and C would be chosen before D. Evaluating the target levels shows that the three species found in B, and two of the three species found in C are already part of the solution set from A and therefore C and B would only add one new species to the solution. D has only two species, but neither of these species have met their desired target levels in the solution set and therefore D has the highest level of complementarity. By choosing D as the second area, all species meet their target and the amount of areas needed for conservation is minimized. The use of complementarity, as demonstrated in this scenario, allows for the most efficient use of resources.

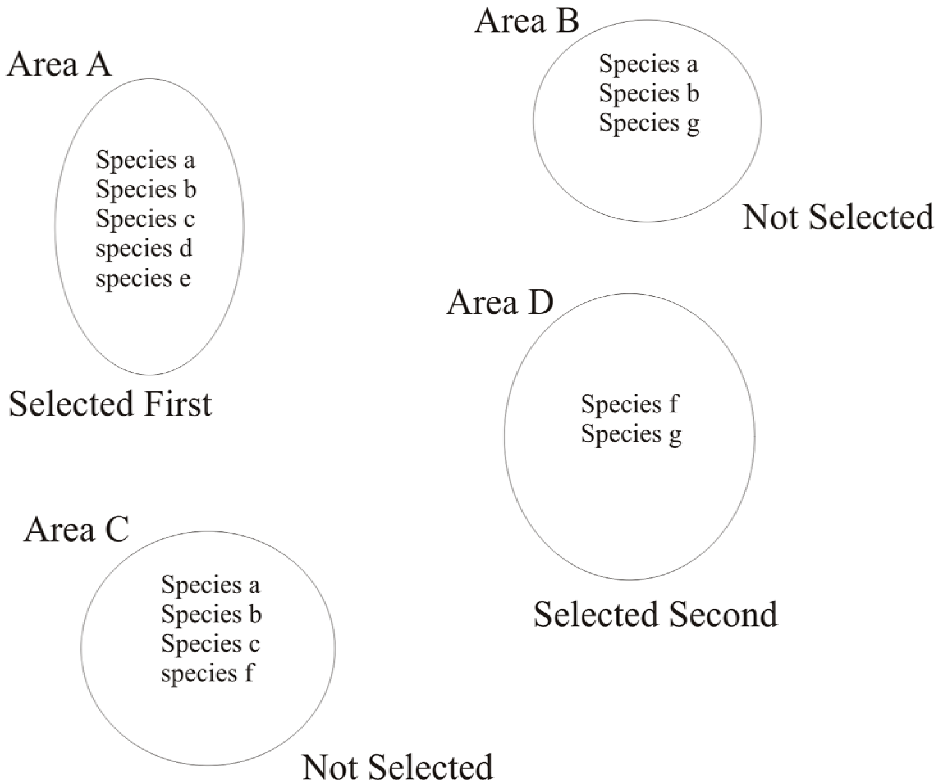


Figure 2.1 Simplified Complementarity Example
This example shows how complementarity works to include all conservation elements at appropriate targets. In this case targets are one occurrence for species a through g. A is chosen first because it has the most unique species and because it has the highest richness. D is chosen next because it adds more to the target levels than any of the other cells– It complements what is already in the solution set. This use of complementarity results in conservation element targets being met in the least area possible.

Because the data sets are rather complicated, and there are time and computational limits to finding a solution, algorithms are imbedded within software programs to calculate complementarity (Margules 1988; Pressey, Possingham, and Margules 1996). Software available for conservation planning that calculate complementarity include C-Plan, ResNet, and Marxan (Margules, Pressey, and Williams 2002).

The prioritization process can be broken down into the following steps:

1) Define the initial set of pre-existing conservation areas such as a preserve system.

2) Select sites with unique conservation elements—these are sites that must be included in the solution set because those elements occur only in one area.
3) Select additional sites using complementarity—those sites with the rarest and most underrepresented conservation elements.
4) If there is a tie between sites, the site adjacent to sites already within the solution set is chosen—this is an optional step not used in this study.
5) If there remains a tie, the site with the lowest index number—lexical order—is chosen.

These processes are repeated until all targets are met (Kirkpatrick 1983; Nicholls and Margules 1992; Pressey and Cowling 2001; Aggarwal 2000; Margules, Nicholls, and Pressey 1988).

OTHER CONSERVATION PLANNING MEASURES

Three additional measurement and evaluation tools were used in this conservation planning study. Both irreplaceability and vulnerability have been used in other conservation planning processes as a post-prioritization evaluation tool (Pressey, Johnson, and Wilson P 1994; Noss et al. 2002). Environmental space graphs have been a tangential part of the literature concerning conservation planning as a way to evaluate and insure data sets represent the entire study area. This study uses environmental space graphs to qualitatively evaluate existing open space and areas prioritized for conservation.

Irreplaceability

Irreplaceability is based on the uniqueness of an evaluation unit, meaning that another unit cannot replace it to meet particular conservation goals or targets (Pressey, Johnson, and Wilson P 1994). For instance, an area containing a species with a 100% target would be irreplaceable because the conservation goals could not be met without including that area. If however an area contained a species with a 20% target, that area would not necessarily be irreplaceable as the conservation goals could be met with the inclusion of other evaluation units. This tool highlights areas that are important for multiple conservation scenarios and the results should be considered for immediate inclusion in conservation lands.

Vulnerability

Vulnerability measures the ability of a population or habitat to resist, adapt, or remain stable during natural or anthropogenic change. Anthropogenic factors contributing to vulnerability include land-use, climate change, invasive species, and increasing human populations. Natural phenomena include fire, flood, drought, and predation. The less likely a system will be able to withstand these types of phenomena, the higher the vulnerability. To evaluate vulnerability, current conditions and projections of stressors must be evaluated (Bradley and Smith 2004; Noss et al. 2002).

Within an urbanizing area a number of stressors affect natural systems. To measure each of these would be complex. Using factors such as central place theory, the continued expansion of urban nodes within the area can be assumed (Herbert and Benjamin 1960). This is further supported by municipal jurisdictions that allows for a central core with full jurisdiction and an area surrounding this core known as the extra territorial jurisdiction. This allows for the identification of areas around those urban cores that are more likely to be developed, at a higher risk of transformation, and therefore in greater need of conservation.

Environmental Space Analysis

Environmental space graphs evaluate the relationship of multiple environmental variables within a defined area. The results of these analyses can be used to create more comprehensive surveys or to better understand the relationships of species to particular environmental variable combinations (Austin and Heyligers 1989; Austin 1998; Margules et al. 1994; Austin, Cunningham, and Fleming 1984). In the case of this study particular environmental variables are graphed with biodiversity records, existing open space, and areas prioritized for conservation (Peralvo, Sierra, and Young 2006). These visual, qualitative displays show the range of relationships within the study and highlight the increased representation of environmental and biodiversity records in prioritized areas.

CAUTIONS: ISSUES WITH CONSERVATION PLANNING AND THIS APPROACH

The purpose of conservation plans is to facilitate better decision-making processes. Conservation planning is often taking place in real time and must use available resources and data to make decisions in a timely manner. In addition, the resulting plans must be flexible enough to incorporate new information. The prioritized areas created through a conservation plan are best-case scenarios of implementation. Even in the most successful programs it has not been feasible to include all areas prioritized through systematic conservation planning. The planning process should be considered dynamic and priorities must be reevaluated as new areas are conserved, as new data is available, and as new conservation planning techniques are developed.

CHAPTER 3: STUDY AREA

The study area is located at 29.5° to 31°N latitude and 97° to 98.3°W longitude and is within the Edwards Plateau, the Blackland Prairie, and the Post Oak Savannah ecoregions. It is centered on the City of Austin, TX and includes Travis, Williamson, Hays, Caldwell, and Bastrop Counties (Figure 3.1). There are over forty municipalities in the study area and numerous regional, state, and federal entities that have jurisdiction. The area consists of over 11,000 sq km (2,740,000 acres/ 4,280 sq miles). The human population in the area has substantially increased over the past 20 years to 1.5 million people in 2006. Continued increases are expected for the coming decades with projected population levels reaching 2.3 to 4.7 million people by 2040. The area is known for its scenic vistas and natural beauty that range from limestone hills with steep ravines dominated by oak-juniper woodlands in the west to prairies and rolling oak savannahs with remnant pine woodlands in the east. These natural features result from distinct combinations of geology, topography, weather, and geography. The resulting biota includes unique karst and spring fauna, migratory birds of the Central Flyway, and plants that are significant on a global scale and in need of conservation.

GEOLOGY

The oldest land masses currently exposed within the study area originated in the Cretaceous Period from 144 to 65 million years ago. The primary source of depositional material is calcium carbonate derived from small sea creatures that lived in shallow seas that intermittently covered the area. Geologic strata exposed today include: Trinity, Fredericksburg, Washita, Woodbine, Eagle Ford, Austin, Taylor, and Navarro Groups (Figure 3.2). The beginning of the Cenozoic period 65 million years ago was marked by a steady retreat of sea level to its current position (Grunig 1977; Ward 2003). The Wilcox and Midway groups are the geologic strata found furthest east in the study area and were deposited during early portions of the Cenozoic (Grunig 1977).

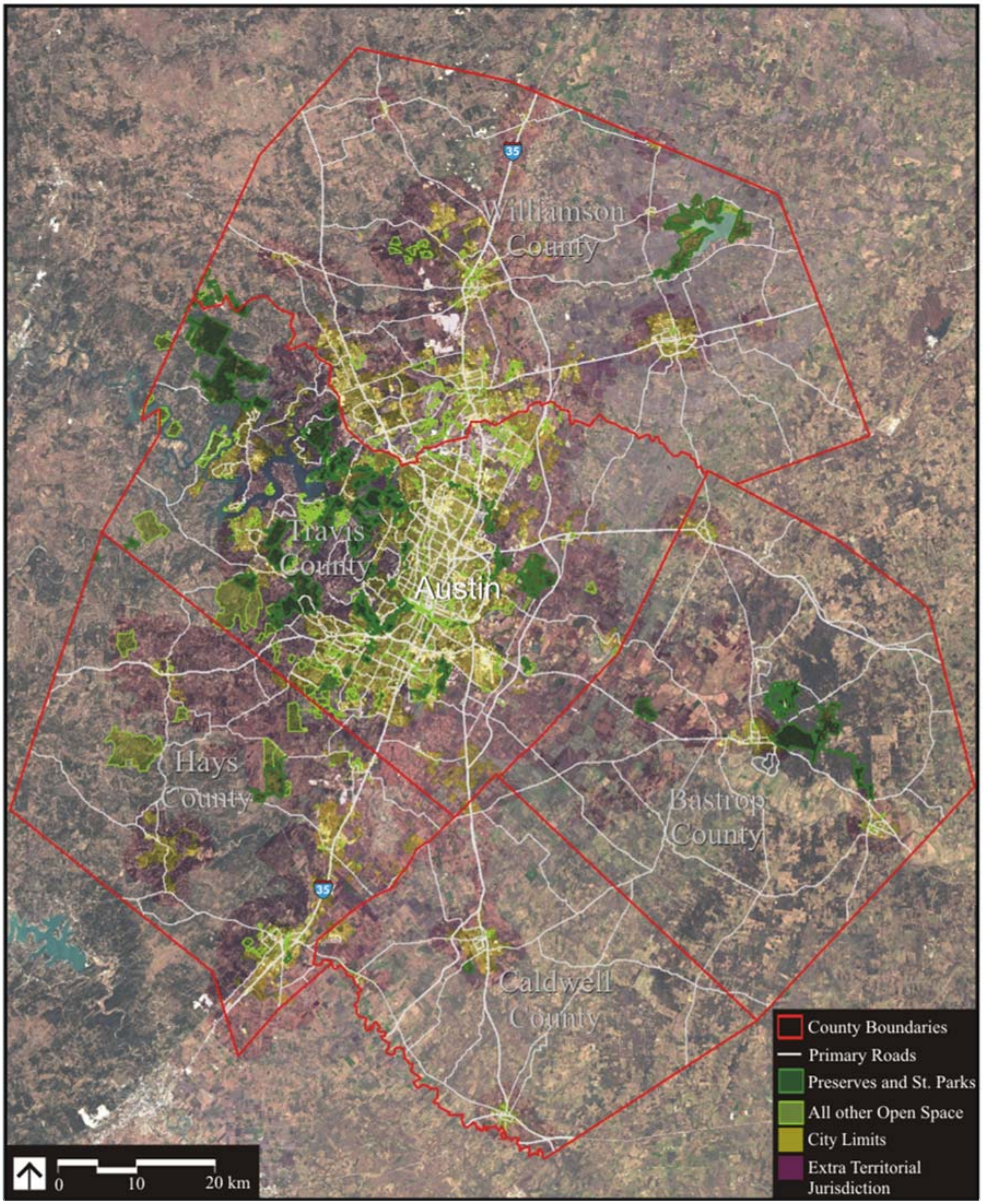


Figure 3.1: Study Area
The study area consists of the five county area around Austin, TX and includes Bastrop, Caldwell, Hays, Travis, and Williamson Counties. The study area is over 11,000 km², with 4.2% of the area in open space. Sources: Landsat 2003, CAPCOG, City of Austin, and local municipalities.

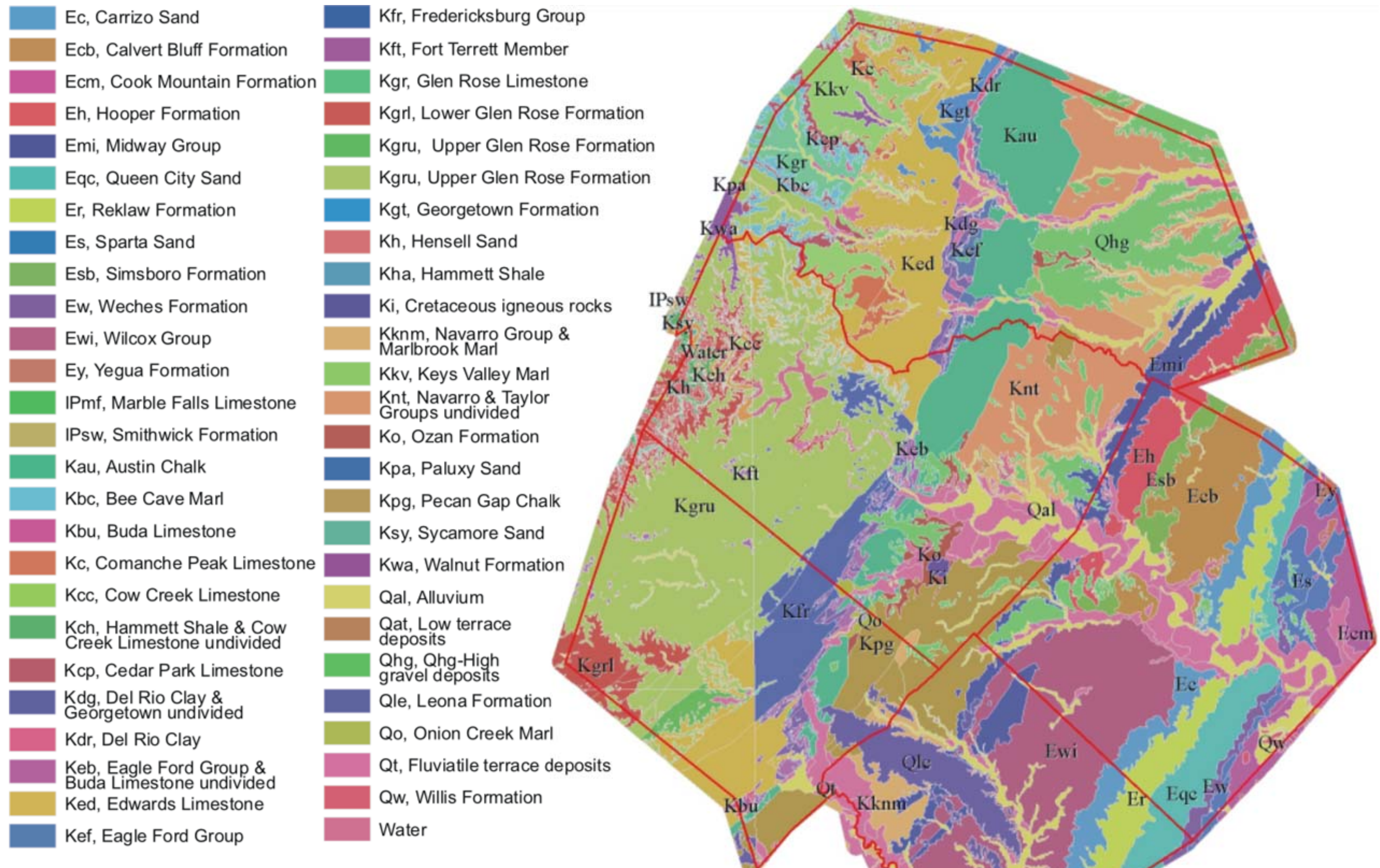


Figure 3.2: Geology
Geologic members from the Bureau of Economic Geology 1:250,000 sheets.
Source: BEG

Some of the landforms within the study area have been continually exposed to weathering for over 65 million years (Johnston 1997). Erosive processes along with the rising of the Llano uplift 23 million years ago created the Balcones Escarpment and the associated Balcones Canyonlands (Ward 2003; Jordan 1977). The escarpment is a string of faults running the length of the study area from North to South with a 91 m (300') elevation change that demarks the higher areas dominated by limestone bedrock to the west from areas with softer limestone, clays and sands to the east (Jordan 1977).

SOILS

Soils of the Hill Country are derived from the underlying rock type with the exception of the alluvia found along river bottoms. Soils in the west generally have a large calcium component and are shallower on ridge tops and slopes. In creek and river bottoms alluvial soils are deeper and contain more organic material. Moving east, the soils become deeper and the limestone component gives way to clay and then sand in eastern sections of the study area. The soils in the eastern two thirds have a higher organic content and are more susceptible to erosion (COA 1980). In all, the UDSA-STATSGO soil survey classified 28 soils within the study area (Figure 3.3). These soils, as with the rock types, determine nutrient and water availability and are therefore significant for conservation (USDA 2006).

TOPOGRAPHY

The study area ranges in elevation from 504 m (1,654') in the west to 80 m (262') in the east making a maximum drop of 424 m (1,391') from west to east (Figure 3.4a). Highest elevations within the study area are found in western Hays County and the lowest elevation are found along the Colorado River floodplain in eastern Bastrop County (USGS 2006).

Slopes within the study area are steeper in the western portions of the study area, corresponding with limestone substrates, and gentler in the eastern portions of the study area, corresponding with the clay and sand substrates (Figure 3.4b). The most significant areas of high slopes occur in the Colorado and Pedernales River

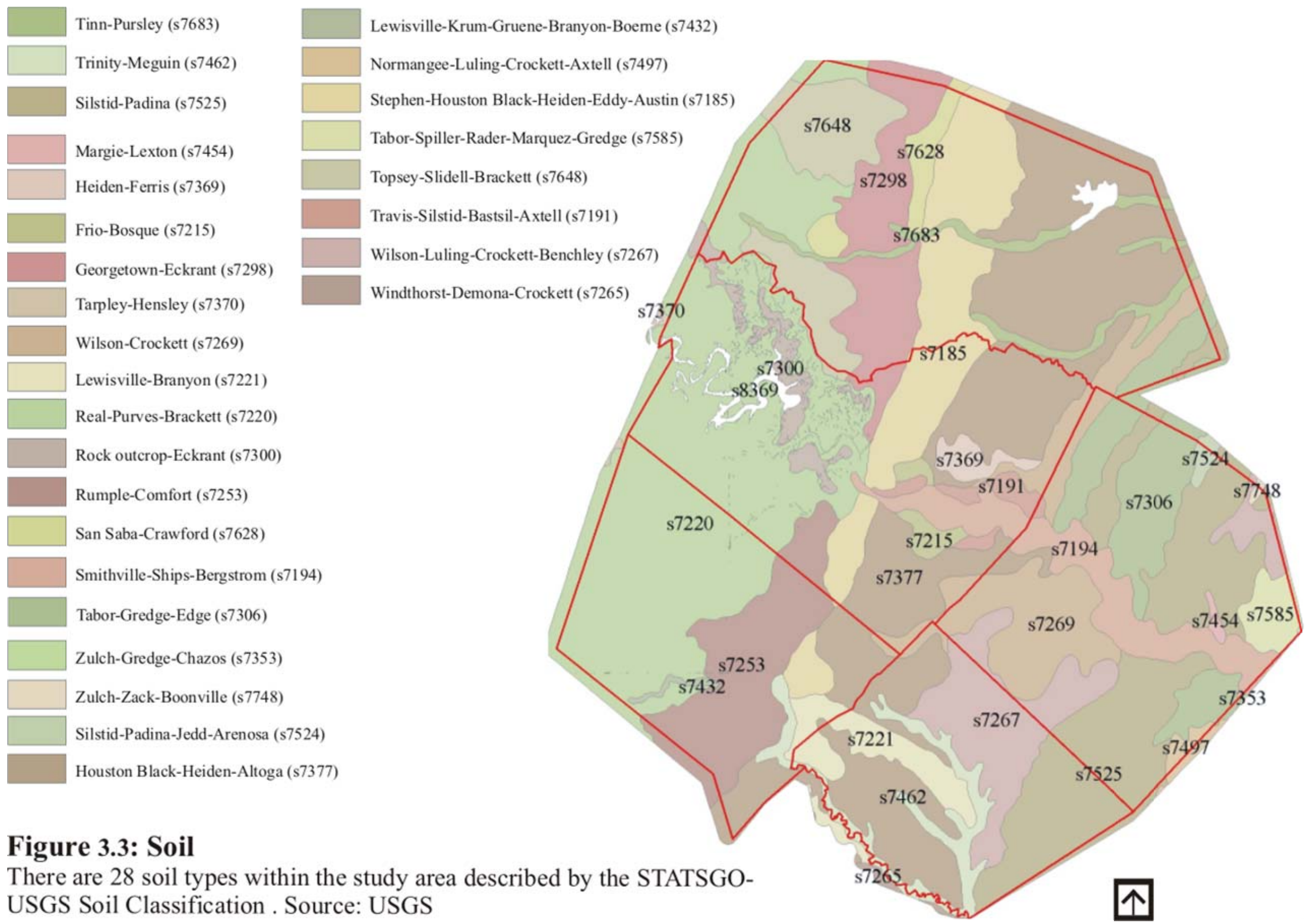


Figure 3.3: Soil
There are 28 soil types within the study area described by the STATSGO-USGS Soil Classification . Source: USGS

Basins. Steep slopes are also found throughout the study area along creek and river bottoms. The largest expanses of flat areas occur in the Colorado and San Marcos River floodplains with significant areas of flat upland in eastern Williamson, Bastrop, and Caldwell County.

CLIMATE

The study area climate is humid subtropical with mild winters and hot summers. Influential air masses include: continental polar and continental Arctic from Canada, maritime polar from the Pacific Ocean, continental tropical from Mexico, and maritime tropical from the Gulf of Mexico (Bomar 1990). The predominant wind is from the south to south-southeast with an average speed of 14.5 kmph (9 mph) (Bomar 1990). Due to the study area's latitude and predominant winds coming from the Gulf of Mexico, the area has long hot summers with relatively few cold spells in winter.

The mean annual temperature for the study area ranges from 18.4 to 20.3°C (65.1 to 68.5°F) (Figure 3.5a). The average low temperature in the coldest month of the year ranges from 1 to 3°C (33.8 to 37.4°F). The average high temperature in the warmest month of the year ranges from 33 to 36°C (91 to 97°F) (Hijmans et al. 2005).

Average annual precipitation ranges from 779 mm to 952 mm (30.5" to 37") (Figure 3.5b), with Austin receiving an average of 810 mm (31.88") (COA 1974; Hijmans et al. 2005). High rainfall periods occur from May to June and September to October. The least amount of rain falls from December to January. On average it rains above 2.54 mm (.1") 49 days per year. The fluctuation in rainfall throughout the year is substantial and irregular to the point that the area is not as lush as areas with equivalent rainfall rates (Johnston 1997; Bomar 1990).

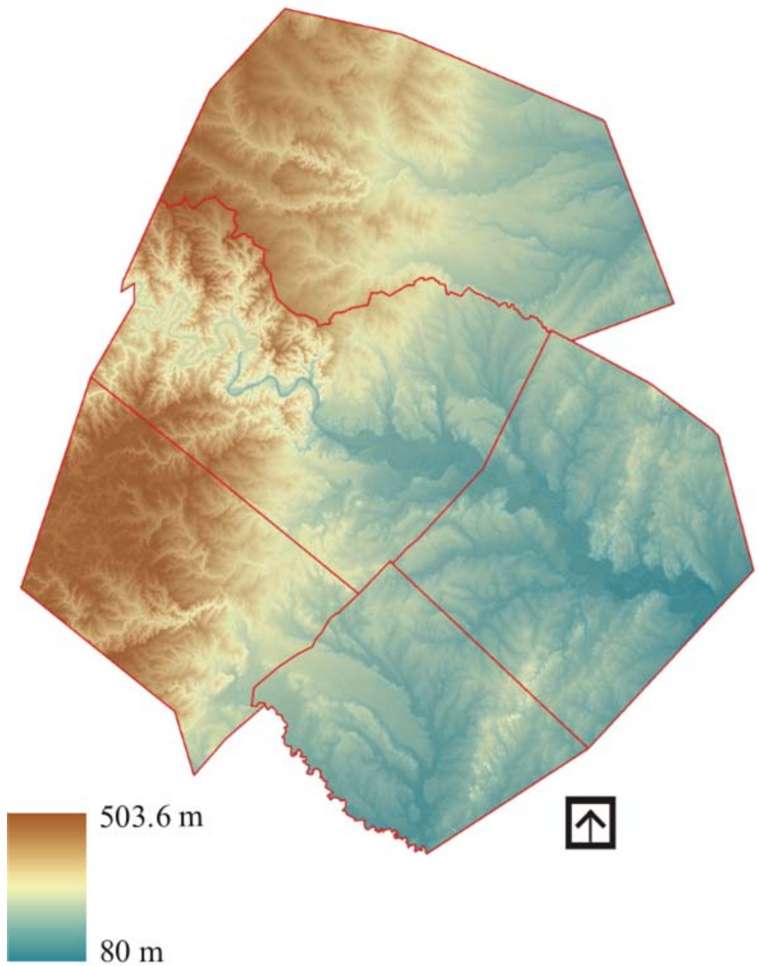


Figure 3.4a: Elevation
The elevation of the study area taken from the 30 m National Elevation Data Set.
Source : USGSS

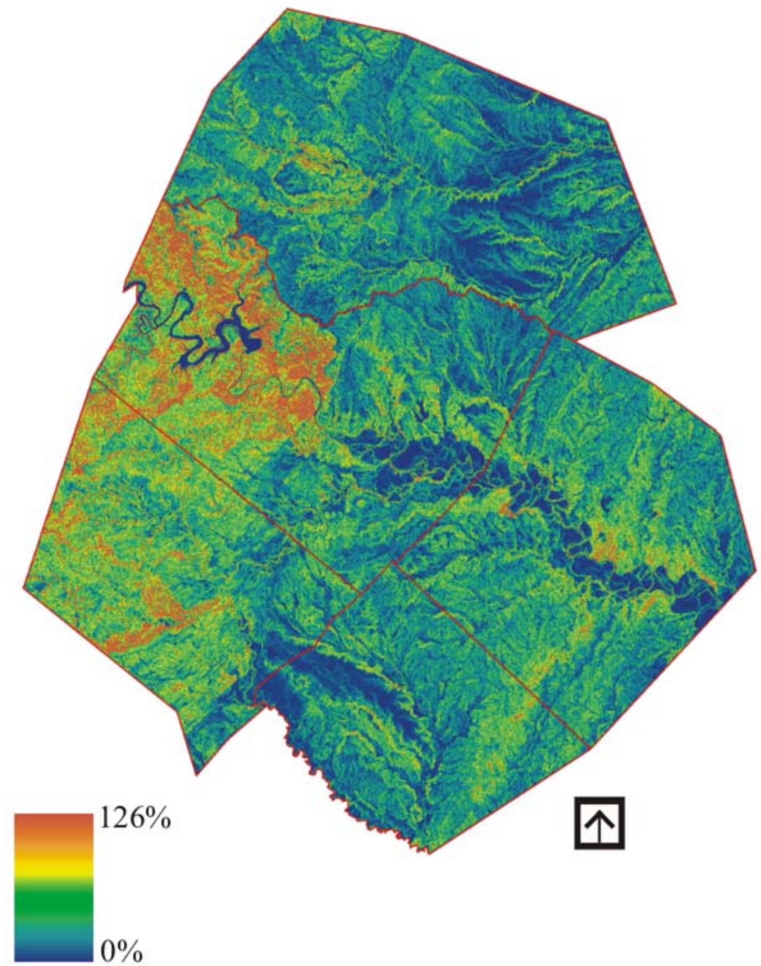


Figure 3.4b: Slope
The slope of the study area derived from the 30 m National Elevation Data Set.

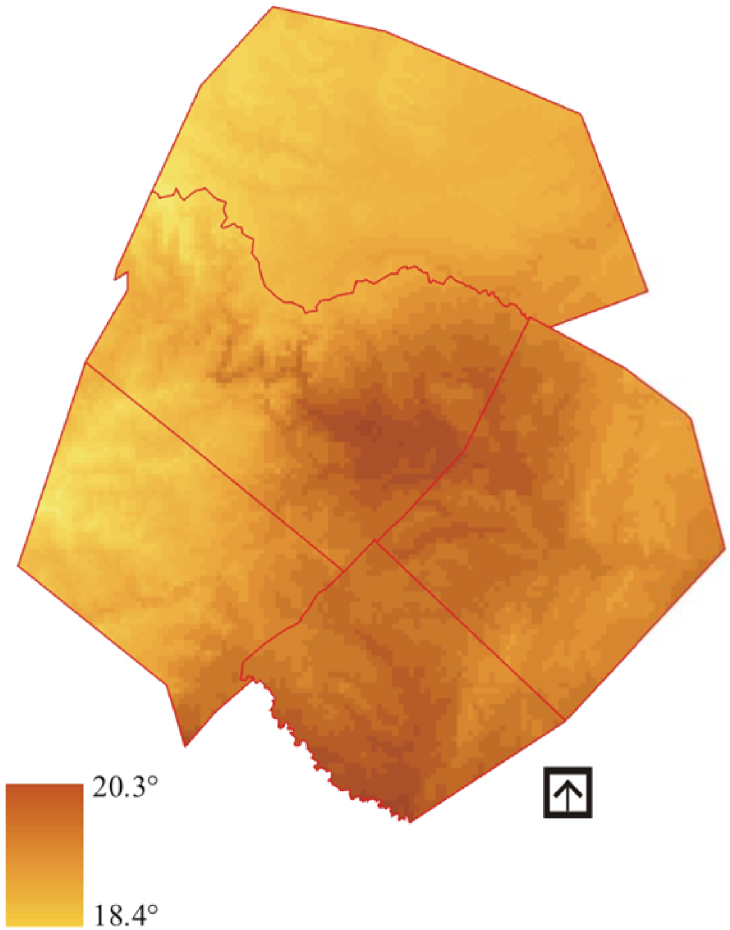


Figure 3.5a: Avergae Annual Temperature
The average annual temperature at 1 km resolution.
Source: Worldclim

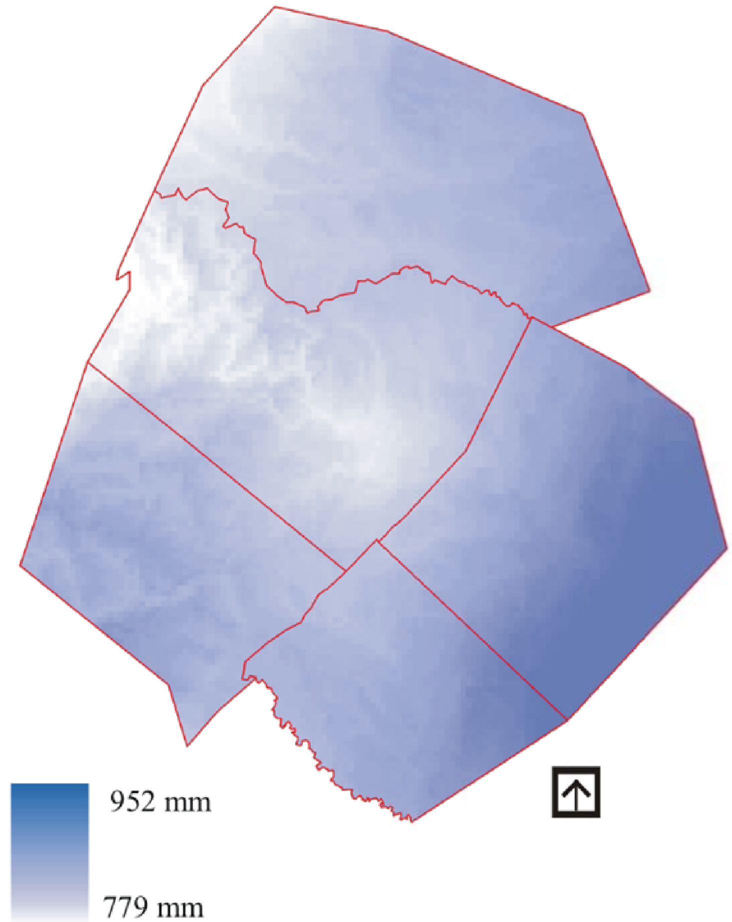


Figure 3.5b: Avergae Annual Precipitation
The average annual preciptation at 1 km resolution.
Source: Worldclim

Intense rain periodically occurs in the study area. In extreme cases, it can drop the equivalent of the mean annual precipitation in one rain event. The most extreme rainfall event in the United States occurred in the study area in Williamson County in 1921 when 970 mm (38.2”) of rain fell in a 24-hour period (Caran and Baker 1986). Southwest of the study area in Medina County, 559 mm (22”) of rain fell in 2 hours and 45 minutes which is the highest known rainfall for that amount of time ever recorded (Caran and Baker 1986).

HYDROLOGY

Three river basins intersect the study area. The Colorado River Basin covers 52% of the study area (Figure 3.6). The Brazos River Basin to the north and the Guadalupe River Basin to the south cover 27% and 21% respectively—the actual rivers of these two basins are outside the study area. The waterways in all basins on the western side of the study area have a dendritic pattern with deeper basins and higher slopes due to the harder underlying limestone. In eastern portions of the study area the drainage pattern is more sinuous with braided stream patterns due to more erodible soils and less topographic relief. These braided patterns are sites of a number of unique species recorded in the Austin Area, including some thought to have disappeared with the creation of the dam system strung along on the Colorado River (Carr 2006).

There are a number of large reservoirs within the study area. Lake Travis, Lake Austin, and Lady Bird Lake are on the main stem of the Colorado River. Decker Lake in Eastern Travis County and Bastrop Lake in Bastrop County are on tributaries of the Colorado. Georgetown Lake and Granger Lake are found along the San Gabriel River in Williamson County. These lakes serve human water needs for drinking, agriculture, energy production, and flood control. They have resulted in large-scale land transformation through permanent flooding of habitat and alteration of natural flow regimes. They have also resulted in pockets of parks around their perimeters.

Flooding within the study area is a usual phenomenon, and frequencies along the Balcones Escarpment are the highest in the United States (Caran and Baker 1986). Runoff from rain events funnel down the western side of the area and converge in the flat eastern portions. The lack of topographic relief results in pools, rising water, and flooding. Areas of impervious cover from urbanization further amplify this natural phenomenon. These natural cycles have given rise to highly diverse plant and animal assemblages that depended upon shifts in flow regimes and flooding (Johnson 2002).

A healthy hydrologic system is vital to humans inhabiting the study area. A number of municipalities have set aside open space specifically for the protection of water quality. The costs of poor watershed management are substantial. The City of Austin projects it will spend 875 million dollars in the next 40 years to partially mitigate water quality issues (Loomis and Moore 1999). These costs do not account for population growth, the entire city jurisdiction, or lands to be annexed in the future.

Edwards Aquifer

The Edwards Aquifer, named after its source geologic member, is a substantial biologic and cultural resource in the study area (Figure 3.6). The aquifer was formed through the dissolution of pockets of softer limestone within the Edwards Limestone, the Fredericksburg group, and the Georgetown Formation leaving the harder members such as the Walnut Formation and Grainstone Member to create the structure of the aquifer (Hauwert, Johns, and Aley 1998). The less permeable Trinity Aquifer forms the lower boundary of the Edwards Aquifer (COA 1974).

The Edwards Aquifer has four zones: a recharge zone—the area where the porous limestone making up the aquifer is exposed at the surface and allows surface water to penetrate into the aquifer; the contributing zone—the upstream portions of watersheds that drain into the recharge zone; the transition zone—the area that is semi-porous on the eastern side of the recharge zone; and the contributing zone within the transition zone—the area that drains into the transition zone (TCEQ 2006). Water enters the aquifer through sinkholes and fractures that are often found in creek bottoms on Barton, Williamson, Bear, Little Bear, Onion, Eanes, and Little Bee creeks in the recharge zone (Hauwert, Johns, and Aley 1998). This water originates from rainfall within the recharge and contributing zones. The combination of extreme rain events and porous creek bottoms makes for sizable, intermittent drainage systems that have substantial fluctuations in flow rates.

The Barton Springs segment of the aquifer covers a total of 401 km^2 (99,200 acres) (NPS and COA 1992). This area runs from near the city of Kyle in the south, to the Colorado River in the north, to the Mount Bonell Fault in the northwest. The two major outlet points for the segment are Barton Springs and Cold Springs. The average flow rate from Barton Springs from 1917 to 1995 was 1,500 lps (53 cfs) (Hauwert, Johns, and Aley 1998). Flow rates through the aquifer are high with recharge over several miles taking as little as 6 hours. This suggests little time for filtration in the aquifer, making conservation and protection of surface water flows critical to the health of the aquifer and associated springs. Over 45,000 people obtain drinking water from the Barton Springs segment and it is used by the following municipalities to partially fulfill their water needs: Austin, Sunset Valley, Manchaca, San Leanna, Buda, Hays, Creedmoor, Niederwald, and Mountain City (Hauwert, Johns, and Aley 1998).

Aquarena Springs is the primary outlet point for the Edwards Aquifer within the southern portion of the study area and is the source of the San Marcos River, which eventually flows into the Guadalupe River. Aquarena Springs is actually a network of approximately 200 springs with a combined average discharge of 4300 lps (152 cfs) (Brune 1981).

Finally, the springs created by the aquifer serve as cultural icons for the cities in the study area. In Austin, it is Barton Springs with over 350,000 visitors per year, in Wimberley it is Jacobs Well, and for San Marcos it is Aquarena Springs (Hauwert, Johns, and Aley 1998). The biotic and societal significance of this aquifer make it a high priority for conservation.

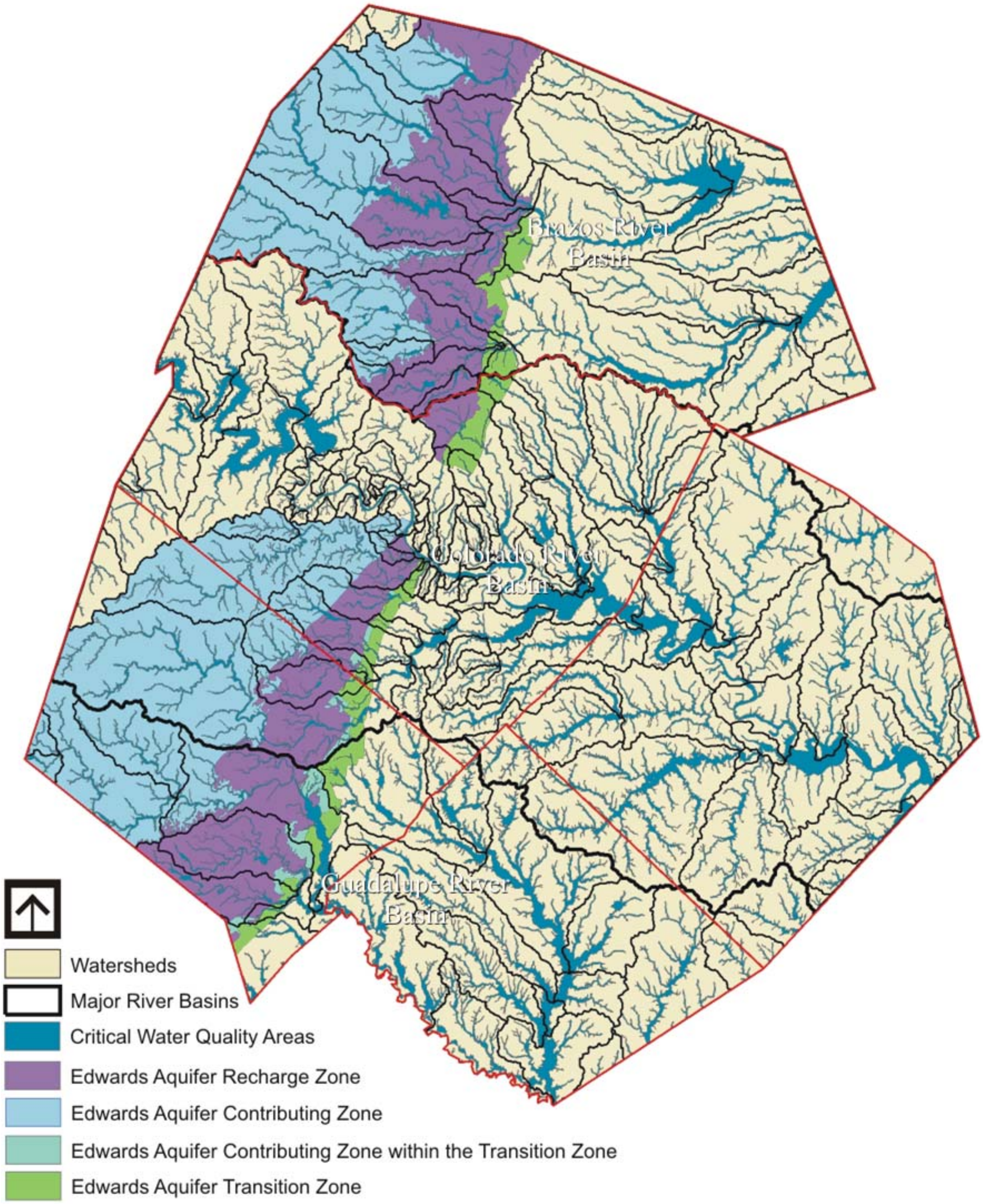


Figure 3.6: Hydrology

The study area consists of three river basins. The Edwards Aquifer traverses the western side of the study area. Critical water quality areas includes the 100 yr Floodplain and stream buffers for streams draining more than 2.6 km^2 (640 acres). Watersheds are a derivation of the City of Austin management watersheds. Sources: TCEQ, CAPCOG, City of Austin

ECOLOGY, FLORA, AND FAUNA

Central Texas is a transition zone of ecological processes, flora, and fauna that are the result of interactions between biotic and abiotic elements over the millennia. Factors influencing the areas ecology and biota include geology, topography, and climate with significant influence from the Balcones Escarpment and the Blackland Prairie. The area is divided into three ecoregions: the Edwards Plateau to the west, the Blackland Prairie through the center, and the Post Oak Savannah to the east (Gould, Hoffman, and Rechenthin 1960). The area has historically supported large mammals and a diverse fauna that have declined sharply with expanded human populations.

Wildlife historically found in the study area included: bison, prairie chickens, canids, black bears, white tailed deer, mountain lions, javelin, quail, wild turkey, waterfowl, and migration passenger pigeons (COA 1974; Doughty 1983). Settlers extirpated much of the wildlife in the 1850s to 1870s. The eradication of bison and other fauna, as well as the control of fire have substantially altered the species composition of the study area resulting in a more homogeneous landscape with significantly fewer native species (Riskind and Diamond 1986).

Area as a Transition Zone

The study area is within a 300 km east-west transition zone of species on a continental scale (MacRoberts and MacRoberts 2003). The transition zone, where species distributions change, is a result of a number of abiotic factors with the Balcones Escarpment and the Blackland Prairies playing key roles in altering species distributions within the study area. These changes in species affinity and abiotic factors fit within the ecoregional classification of the study area.

The topographic barrier of the Balcones Escarpment and the associated Balcones Canyonlands create variations in rainfall, temperature, humidity, elevation, and slope that affect the natural processes occurring in its vicinity and create niche habitats. The vegetation mimics this transition with many of the current species along the escarpment having their origins in the eastern forest that has retreated to the eastern border of the study area due to a drier, warmer climate and created isolated populations along the

Edward’s Plateau (Hafner 1993). In addition, the physical elevation shift in the escarpment serves as a barrier to dispersion for a number of species (Johnston 1997; Neck 1986).

The Blackland Prairie is a transition zone for species as well as a barrier to east-west mobility. Gehlbach (1991) found that 57 mammals, 67 songbirds, and 78 reptiles show a gap or a spatial anomaly along the Edwards Plateau / Blackland Prairie line. The habitats associated with the prairie became more prevalent as a result of the warming trend at the start of the Holocene epoch 10,000 years ago. The slow retreat of more mesic species east was paired with an increase in grassland species. A number of animal species can be found on both sides of the prairie but are not found in it including: the eastern fence lizard, copperhead, fox squirrel, eastern wood rat, and tufted titmouse. This evidence points to the study area being a heterogeneous assortment of habitat types, all of which should be considered for conservation.

Edwards Plateau

The western portion of the study area is in the Edwards Plateau Ecoregion (Gould, Hoffman, and Rechenthin 1960). It is predominantly covered by oak / juniper savannah on limestone-based soils. There are a number of unique plant communities that result from habitats created by the canyonlands. Approximately 2,300 vascular plants are native to the Edwards Plateau, 10% of which are endemic (Correll and Johnston 1970, Johnston 1997).

Vegetation of the Edwards Plateau includes oak-juniper savannah, grasslands, and mesic plant communities within canyonlands. Dominant woody species include: live oak (*Quercus fusiformis),* ashe juniper (*Juniperus ashei*), Texas oak (*Quercus texana*), and Texas ash (*Fraxinus texensis*). Grasslands historically dominated flatter areas with better soil and recurring fire. Steep slopes have juniper on the western and southern exposures, and short-stature mixed woodlands on northern and eastern slopes. Stream sides and creek bottoms are habitats for a variety of mesic plants including: bald cypress (*Taxodium disticum*), sycamore (*Platanus occidentalis),* *Buttonbush* (*Cephalanthus occidentalis*), box elder (*Acer negundo*), pecan (*Carya* *illinoensis*), and eastern cottonwood (*Populus deltoides*) (Riskind and Diamond 1986; Diamond, True, and He 1997; Johnston 1997).

Blackland Prairie

East of the escarpment is the Blackland Prairie Ecoregion (Gould, Hoffman, and Rechenthin 1960). Plants commonly found in the prairie include: little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropgon gerardii*), Indian grass (*Sorghastrum nutans),* sideoats grama, (*Bouteloua curtipendula*), and tall dropseed (*Sporabolus asper*) (Bryant 1986; Collins, Smeins, and Riskind 1975). Only remnants of this vegetation remain in the area due to transformation of the native prairies into agricultural production (Diamond, True, and He 1997).

Post Oak Savannah and Lost Pines

The eastern edge of the study area is in the Post Oak Savannah Ecoregion (Gould, Hoffman, and Rechenthin 1960). It is a mosaic of grassland and woodland divided by riparian bottomlands. Common plant species include: post oak (*Quercus stellata*), black jack oak (*Quercus marilandica*), eastern red cedar (*Juniperus virginiana*), yaupon (*Ilex vomitoria*), American beautyberry (*Callicarpa americana),* trumpet creeper (*Campsis radicans*), little bluestem (*Schizachyrium scoparium*), and silver bluestem *(Bothriochloa saccharoides)* (Diamond, True, and He 1997; McMahan, Frye, and Brown 1984).

Near the city of Bastrop, are the “Lost Pines” or “Pineywoods”—a disjunct population of loblolly pine (*Pinus taeda*). This remnant population is due to a unique combination of sandier soils, rolling topography, and ample moisture. Within the study area itself this area is considered less diverse with respect to overall species richness (Carr 2006). Ferdinand Roemer, an early German explorer and botanist who traveled through Central Texas, described the Pineywoods as “sandy, infertile pine covered hills” (Weniger 1984). In neighboring counties the same Carrizo Sands substrate supports diverse plants including some endangered species (Carr 2006). While not equally high in richness, the lost pines are an interesting plant association and have cultural value.

SPECIES AND SPECIES ASSEMBLAGES OF CONCERN

Texas Parks and Wildlife Department lists 95 species in the area as rare, threatened or endangered (TPWD 2007). Of these 25 are federally listed as endangered, 1 as threatened, 6 are candidates for listing, and 8 have been delisted (TPWD 2007). At the state level 16 are listed as endangered, 2 as endangered/ threatened, and 11 as threatened (TPWD 2007).

The Texas Heritage Database and other source data used for this study include 40 species and 12 species assemblages. Sixteen of the species are endangered. Thirty of the species and two of the species assemblages have fewer than 20 populations globally or in the state, and 10 have 20 to 200 populations globally or in the state (TNC 2005; TPWD 2005; NPAT 2006; TMM 2006; USGS 2006).

Many of the rare, threatened, and endangered species fall into four categories: migratory birds, vascular plants, karst fauna, and spring fauna. The area is on the flight path for a number of migrating birds, a number of which are endangered, such as the whooping crane. In addition, it is the breeding ground for the federally endangered golden-cheeked warbler (*Dendroica chrysoparia*) and the black-capped vireo (*Vireo atricapilla*). Conservation efforts for these two bird species have resulted in more than 30,000 acres of land protected and managed for their habitat (BCCP 2007).

The western portions of the study area are known for plant endemism (Johnston 1997). Some vascular plants of concern are: texabama croton (*Croton alabamensis var. texensis*), sandhill woolywhite (*Hymenopappus carrizoanus*), canyon mock-orange (*Philadelphus ernestii*), Correll's false dragon-head (*Physostegia correllii*), bracted twistflower (*Streptanthus bracteatus*), Texas wild-rice (*Zizania texana*), Texas amorpha (*Amorpha roemeriana*), Texas barberry *(Berberis swaseyi)*, giant helleborine (*Epipactis gigantean*), Texas fescue (*Festuca versuta*), glass mountains coral-root (*Hexalectris nitida*), Heller's false-gromwell (*Onosmodium helleri*), Engelmann bladderpod (*Physaria engelmannii*), and Buckley tridens (*Tridens buckleyanus*) (TNC 2005; TPWD 2005).

The karst fauna are one of the most diverse in the Southwestern United States and show a level of diversity and divergent evolution comparable with the Galapagos Islands (BCCP 2004). Rare cave fauna include: Coffin Cave mold beetle (*Batrisodes texanus*) Tooth Cave blind rove beetle (*Cylindropsis sp.1*), Tooth Cave ground beetle (*Rhadine Persephone*), Tooth Cave pseudoscorpion (*Tartarocreagris texana*), Kretschmarr Cave mold beetle (*Texamaurops reddelli*), Bee Creek Cave harvestman (*Texella reddelli*), Bone Cave harvestman (*Texella reyesi*), and Tooth Cave spider (*Neoleptoneta myopica*) (USGS 2006; TPWD 2005; TNC 2005).

Spring flora and fauna, like the karst fauna, are associated with the geology of the Edwards Plateau and Aquifer. They are animals limited in mobility and habitat due to the aquatic nature of their life histories. They include: San Marcos salamander (*Eurycea nana*), Georgetown salamander (*Eurycea naufragia*), Blanco River Springs salamander (*Eurycea pterophila*), Texas blind salamander (*Eurycea rathbuni*), Blanco Blind salamander (*Eurycea robusta*), Barton Springs salamander (*Eurycea sosorum*), Pedernales River Springs salamander (*Eurycea sp. 6*), Jollyville Plateau salamander (*Eurycea tonkawae*), Austin blind salamander (*Eurycea waterlooensis*), fountain darter (*Etheostoma fonticola*), large spring gambusia (*Gambusia geiseri*), and Texas wild-rice (*Zizania texana*) (USGS 2006; TPWD 2005; TNC 2005).

HUMAN LAND USE

Early Humans

Artifacts show continuous human habitation for the past 12,000 years, perhaps longer, in the study area (Hester 1986). The native people who lived in the area transformed the landscape to meet their needs. The extent of this transformation is unknown as little historical or archeological information is available. From 1718 to the 1830s Spanish explorers and settlers, moving north from Mexico had an impact on the area. Main settlements, however, were in San Antonio and their impact as far north as the study area was minimal in comparison to Anglo settlement after 1830 (Palmer 1986; Weniger 1984).

Early Anglo settlers found what seemed like an endless supply of natural resources (Doughty 1983). Immigrants claimed cheap land, fertile soils, and good hunting grounds. The abundance of wildlife and beauty of the landscape compelled many early explorers to describe the grandeur and abundance of the study area, especially noting the Blackland Prairie. Their stories suggest there was an abundance of bison, black bear, panthers, and deer (Doughty 1983; Olmsted 1857). In addition to game mammals, explorers encountered large expanses of riparian woodlands and upland woodlands in the post oak savannah as well as mature stands of post oak, black jack oak, and live oak on the Edwards Plateau (Weniger 1984).

The idea of endless supplies of natural resources held claim until the 1850s when people began to see marked decreases in game, and landscape issues such as erosion became common. Because of this land transformation, much of which occurred by 1860, and the lack of public lands within the study area, there is limited information on rare species, remnant communities, and the overall historic condition of the environment (Diamond, True, and He 1997; Bezanson 2000). This is particularly true of the Blackland Prairies where human transformation of the environment has been ubiquitous due to good soils, abundant game, and minimal topographic relief.

Current and Future Human Populations

The area's 2006 population was over 1.5 million people, a 25% increase over 2000 numbers, with the majority of the population in Travis County (Table 3.1). Population growth is expected to continue and by 2040 the population is projected to be 2.3 to 4.7 million people (TWDB 2002; TSDC 2006). All projections expect a substantial increase in population resulting in an increased need for open space, while increasing the cost of open space due to increasing demand on finite land resources.

Table 3.1 Current and Future Populations

County	2006 Population	2040 Population Projections	
		Low	High
Bastrop	71,726	97,624	357,683
Caldwell	35,562	61,505	111,212
Hays	133,931	264,321	584,642
Travis	928,037	1,175,905	1,971,837
Williamson	349,982	725,786	1,696,252
Total	1,519,238	2,325,141	4,721,626

(TWDB 2002, TSDC 2006)

The Envision Central Texas project, formed in 2001 in response to this expected growth, created a community vision of future land use within the five county study area. The process used public input through workshops and surveys to evaluate a number of land use scenarios to accommodate future populations. Citizen input—approximately 13,000 participants—overwhelmingly selected increased density around existing communities and infrastructure rather than sprawl (ECT 2004). In addition to an overall vision, participants rated their top ten concerns for future growth. Listed with their associated ranking in the survey, six of the top concerns are associated with open space: 1) Congestion, 2) Air Quality, 5) Water Quality, 6) Water Availability, 8) Parks and Open Space, and 9) Land Use (ECT 2004).

OPEN SPACE AND CONSERVATION

Open space lands are the instruments by which conservation is occurring in the study area. Central Texas has a number of successful conservation programs that have conserved land for biodiversity and ecological function in portions of the study area. Acquisition of open space has been motivated by cultural conservation, recreation, aesthetics, ecological services, and biodiversity. In the 1970s a number of factors began to change the way people perceived the environment and resulted in increased support for open space as a means to mediate problems associated with the loss ecological function and biodiversity. The publication of *Silent Spring* (1962) by Rachel Carson brought awareness to the destruction of ecological functions that are imperative to a society's subsistence. Her book highlighted a chemical spill within the study area on Town Lake, now Lady Bird Lake. The spill caused one of the largest fish kill ever seen in the area and contaminated the sediments of the lake for decades. Increased awareness of growing environmental problems affected policies and legislation on local, state, and federal levels. Actions to address these issues ranged from sweeping legislation to the acquisition of greenbelts along local creeks to protect water quality (COA 1970).

Federal legislation established millions of acres in conservation lands through the Endangered Species Act and the Clean Water Act. The Endangered Species Act (1973), in response to declines in biodiversity, mitigates the "take" of endangered species through the protection of habitat, monitoring of species, and mitigation banks. The Clean Water Act (1977), passed in response to declines in water quality, mandates mitigation of issues related to water quality, flooding, and erosion. Both of these pieces of legislation have resulted in monitoring programs at the local, state, and federal levels with mitigation tools including land management practices, watershed regulation, and open space acquisition.

Efforts to save open space within the study area have resulted in 4.1% of the study area in some type of open space for active and passive recreation, cultural sites, preserves, and areas with conservation easements (Figure 3.1). This number is based on a semi-comprehensive data set created in January of 2006 that originated from multiple sources including local municipalities, conservation organizations, and state and federal agencies. Open space areas include 468 km^2 (115,641 acres) in 556 parcels of land. Major open space holdings can be seen in Table 3.2. The distribution of open space is biased towards the central western portions of the study area due to the two primary driving forces for land conservation—biodiversity and water quality. In addition, the lack of topographic relief, extent of transformation, lack of urbanization pressure, and ongoing farming operations have made the eastern portions of the study area less affected by conservation.

Table 3.2 Major Open Space Holdings

Owner	Area (km^2)	Area (acres)
City of Austin	116	28,706
Private Ownership with Conservation Easements	91	22,366
Texas Parks and Wildlife Department	74	18,228
U.S. Fish and Wildlife Service	56	13,784
Lower Colorado River Authority	37	9,056
Travis County	35	8,572
The Nature Conservancy of Texas	17	4,154

Previous and ongoing open space acquisition and easement programs have substantially increased conservation lands within recent decades. These programs include: the Austin Tomorrow Plan, water conservation programs, biodiversity conservation programs, and ecoregional conservation plans.

Austin Tomorrow Plan

Components of the Austin Tomorrow Plan dealing with open space resulted from studies in the 1970s that prioritized environmentally sensitive areas (COA 1974). Major issues addressed by the plan included: the preservation of open space outside urbanized areas, protection of water quality and quantity, and control of urban sprawl. The plan discouraged development in areas containing unique plant or animal species, topographically sensitive features, aquifer recharge, and areas with high agricultural value. Sensitive areas and areas for development were determined through a criteria based decision process that ranked areas according to a number of attributes (COA 1974, 1980). This study shares many of the foundational beliefs of the Austin Tomorrow Plan with an additional three decades of evidence showing the benefits of open space and the availability of more refined planning processes.

Water Conservation Efforts

A deep cultural attachment to one of the city's hallmark locations, Barton Springs, the need and desire to protect drinking water, and the protection of aquatic endangered species has led to a substantial effort to acquire and protect open space in the recharge and contributing zones of the Barton Springs Segment of the Edwards Aquifer. This effort began with the Barton Creek Green Belt System and Wilderness Park initiated in the 1980s. The effort continued with the passing of Proposition II in 1999 that allowed the City of Austin to use bond money for the acquisition of open space in fee simple or easements within the recharge and contributing zones. A number of organization and municipalities including the City of Austin, the Nature Conservancy, and the Hill Country Conservancy have participated in efforts to protect the Edward's Aquifer. Some of the largest contiguous pieces of open space within the study area have been set aside for conservation of water quality over the aquifer. Many of the properties are protected through conservation easements that put restrictions on the development of the property in perpetuity. Under these easements traditional agricultural land uses are often permitted and portions of the properties remain developable. Within the recharge and contributing zone there are 142.6 km^2 (35,239 acres) in open space. Of this amount, 79.8 km^2 (19,712 acres) are owned privately with easements to protect water quality.

Ecosystems Conservation Efforts

The Nature Conservancy of Texas has completed an Edwards Plateau Conservation Plan that includes the western third of the study area and is in the process of completing the Crosstimbers Conservation Plan that includes the eastern two thirds of the study area (TNC 2007, 2004). The plans are developed through a workshop consensus methodology outlined by and instituted on a national level by the Nature Conservancy that evaluates ecoregional conservation priorities. The process incorporates raw data, expert opinion, and a stakeholder process to determine conservation priorities (Groves et al. 2002). While there is some debate as to what defines an ecosystem, there are a number of practical reasons to break up the landscape as the Nature Conservancy has done. A number of important conservation planning elements often align with ecoregional boundaries including: land use, wildlife, and plant communities.

The plans consist of a narrative description of the ecoregion, description of conservation elements including species and assemblages, and areas prioritized for conservation of these elements. The conservation priorities are broken up into aquatic and terrestrial portfolios and are rather large areas. In the Edwards Plateau Conservation Plan there are 105 priority areas with an average size of over 352 km^2 (87,000 acres). The information is used for general knowledge and to give the Nature Conservancy staff priority areas in which to find lands for conservation easements or purchase.

Biodiversity Conservation Efforts

Large tracts of land have been set aside for conservation in compliance with the Endangered Species Act to mitigate the destruction of habitat. Four significant regional habitat conservation plans (RHCP) have been initiated in recent years including the Balcones Canyonlands RHCP, the Williamson County RHCP, the Lost Pines RHCP, and the Hays County RHCP. Of these the Balcones Canyonlands Plan is the most established and has had the greatest impact on the acquisition of open space.

The Lost Pines, Hays, and Williamson County Plans are in varying stages of planning and implementation. The Lost Pines HCP covers a 523 km^2 (124,000 acre) area inhabited by the endangered Houston Toad (*Bufo houstonensis*). The 124,000 acres in the HCP was designated through analysis of substrate and vegetation combinations that are known habitat for the toads. This plan assumes that Bastrop County could not raise the capital necessary for a refuge and instead relies on voluntary land use and development density restrictions to protect open space, while allowing incidental take, in the form of habitat loss and degradation, on 14.6 km^2 (3,608 acres) in the planning area (Bastrop 2006). The United States Fish and Wildlife Service is currently evaluating the plan for approval.

The Williamson County plan covers the Bone Cave harvestman (*Texella reyesi*), Coffin Cave mold beetle (*Batrisodes texanus*), golden-cheeked warbler (*Dendroica chrysoparia*), black-capped vireo (*Vireo atricapillus*), and further investigation of the Georgetown salamander (*Eurycea naufragia)* (ACI 2007). The proposed RHCP calls for the outright purchase of at least nine karst faunal areas (KFA) over a 17 year period with sizes ranging from 40 to 90 acres, as well as a commitment to apply for federal funds to purchase an addition six KFAs (ACI 2007). For mitigation of golden-cheeked warbler habitat, the plan calls for the purchase of 1,000 acres of habitat in neighboring Burnet County. Black-capped vireo habitat is not well established in Williamson County but the proposed RHCP would create a fund to finance black-capped vireo habitat restoration projects. Finally the project would initiate a 5-year study of the Georgetown Salamander (ACI 2007).

The Hays County RHCP is in the process of identifying the scope of the plan. Species likely to be included in the plan are Golden-cheeked warbler (*Dendroica chrysoparia*), black-capped vireo (*Vireo atricapilla*), San Marcos salamander (*Eurycea nana*), Texas blind salamander (*Eurycea rathbuni*), fountain darter (*Etheostoma fonticola*), Comal Springs dryopid beetle (*Stygoparnus comalensis),* Comal Springs riffle beetle (*Heterelmis comalensis*), and Texas wild-rice (*Zizania texana*) (Loomis 2007). The overall mechanisms of implementation are still being discussed but will surely include open space acquisition.

Within the study area the Balcones Canyonlands RHCP has been the most intricate and largest open space program. U.S. Fish and Wildlife Service (USFWS) began the plan in 1996 as a reaction to habitat loss of the golden-cheeked warbler (*Dendroica chrysoparia*) and black-capped vireo (*Vireo atricapilla*). It was the first regional, multi-species plan approved by USFWS. Major partners within the RHCP include the City of Austin, Travis County, USFWS, the Lower Colorado River Authority, the Nature Conservancy of Texas, and Travis Audubon Society.

Through this partnership habitat is being acquired and actively managed for the needs of the two primary species as well as canyon mock-orange *(Philadelphus ernestii),* bracted twist-flower *(Streptanthus bracteatus),* Bee Creek Cave harvestman *(Texella reddelli),* and Kretschmarr Cave mold beetle *(Texamaurops reddelli)* (BCCP 2004). Prioritization of BCCP sites for acquisition was based on the quality of habitat for endangered species, geology, availability, affordability, location, vulnerability, manageability, and accessibility. Specific geologic layers indicated habitat for golden-cheeked warbler, black capped vireo, and karst features. The Fredericksburg group supports the plant communities that are home to the black-capped vireo, while the Glen Rose Formation supports golden-cheeked warbler habitat that includes dense stands of junipers found on steep slopes (BCCP 2004).

Under the Balcones Canyonlands RHCP 30,428 acres will be acquired for bird habitat and 62 karst features will be included in the preserve system (BCCP 2004). As of

2007, almost 28,000 acres of bird habitat is included in the preserve with 44 karst features (BCCP 2007). Land acquisition programs to reach the RHCP goal are ongoing.

There have been extensive conservation plans within the study area in recent decades that have partially mitigated the destruction of habitat and environmental quality due to expanding human populations. These plans have reacted to development pressures and have biased the western-central portions of the study area. The eastern two thirds of the study area, as well as southwest portions of the study area have not seen the same development pressure and as a result are lacking in open space. This lack of open space in large portions of the study area, along with the substantial, expected population increase, makes a comprehensive conservation plan for the area the natural next step.

CHAPTER 4: METHODS

This study applied systematic conservation planning methodologies in the greater Austin area through a step-wise area prioritization process to determine conservation priorities following Margules and Pressey (2000). Information used to determine conservation priority areas included biodiversity, environmental, and land use data. Particular attention focused on biodiversity and water resources, as they are the major motivators of conservation in the study area. Forty prioritization scenarios showed the effect of different target levels for conservation elements on the resulting solution sets. Solution sets ranged in size from a slightly increase over existing open space to a quarter of the study area.

Evaluation of solution sets and the study area looked at total area, spatial patterns, representation in environmental space, irreplaceability, use of lexical order, and overall feasibility. Environmental space graphs showed the relationship of environmental variables to biodiversity records, existing open space, and areas prioritized for conservation. Irreplaceability highlighted areas with a high reoccurrence rate over multiple prioritization runs. Feasibility was looked at qualitatively by addressing general open space trends in the study area in relation to particular solution sets.

DATA SOURCES

A number of sources contributed to biotic and environmental data used for this study (Table 4.1). The primary source of biodiversity records included the Heritage Databases from The Nature Conservancy of Texas and Texas Parks and Wildlife Department (TNC 2005; TPWD 2005). Additional sources of biodiversity data included Texas Memorial Museum, United States Geologic Survey, and the Native Prairie Association of Texas (NPAT 2006; TMM 2006; USGS 2006).

The Heritage Database includes historic records from Herbaria and Museums, as well as data acquired from ongoing fieldwork by multiple organizations. The data are polygon shapefiles consisting of Element Occurrences (EO) that are predominately circles ranging in diameter from 200 m to 16 km. Each EO record represents a population location for a species or species assemblage. When it is uncertain whether there is one population or more, the circle encompasses all populations in question. This procedure results in circles that denote potential habitat and no longer represent a single location of a population. The goal of the database project is to provide data for statewide analysis of conservation priorities.

Data regarding fundamental abiotic features of the study area came from multiple sources in five categories: substrate, topography, climate, water, and land use (Table 4.1). Substrate data included information on geologic and soil types. Topographic data included an elevation model. Climate data included information on factors associated with temperature and precipitation levels. Water data represented water resources such as the Edwards's aquifer, floodplains, stream networks, and watersheds. Land use data included land fragmentation, current jurisdictions, and future land use scenarios.

Table 4.1 Data Sources

Type of Data	Source	Year Obtained	Type
Biodiversity Records-Heritage Database	Texas Parks and Wildlife Department	2004	vector
Biodiversity Records-Heritage Database	The Nature Conservancy of Texas	2005	vector
Biodiversity Records-Bufo houstonensis Records	Texas Memorial Museum	2007	point
Biodiversity Records-Cave Invertebrates	USGS	2006	point
Biodiversity Records-Prairie Remnants	Native Prairie Association of Texas	2006	vector
Geologic Rock Types	USGS	2006	vector
Soil Data (STATSGO)	USDA	2006	vector
National Elevation Data Set	USGS	2006	raster
Climate Data	Worldclim	2006	raster
Stream Network	CAPCOG	2006	vector
Floodplain	CAPCOG	2006	vector
Edwards Aquifer Zones	TCEQ	2006	vector
Watersheds	City of Austin	2006	vector
Land Parcels	CAPCOG	2006	vector
City and Extra Territorial Jurisdiction Limits	CAPCOG	2006	vector
Preferred Development Scenerios	Envision Central Texas	2006	raster

DATA EVALUATION AND PROCESSING

The initial data treatment converted all data to a uniform format and evaluated usability. The extent of area being analyzed consisted of the area slightly larger than the county boundaries, encompassing a total area of 11,439 km². All data was converted to the WGS 84 UTM 14N (meter) projection. In addition to putting the data in the same projection, data were evaluated for coverage, usability, and patterns within the study area. Numerous data sources other than those used occurred at scales or resolution unusable for this study.

Biodiversity Data Evaluation and Processing

Only Element Occurrences (EO) defined by 200m circles or irregular polygons in the TNC and TPWD data were used in the prioritization process. While this left out crucial data, actual locations of habitat could not be determined at a reasonable scale for some records. As the Heritage Database was the predominant data source, all species and species assemblage data were manipulated to match 200 m diameter EOs for consistency. The 200 m diameter circle can be thought of as error bars around the actual record, making this procedure more conservative than just using point data. For instance, a point would always be contained by one evaluation unit. With a 200 m diameter EO, a record has the potential to occur in four evaluation units. In addition, to use probabilistic data—described below—there must be an area by which the expectation or probability of occurrence can be calculated.

While this process did standardize the data it also created some problems. First, the 200 m circle does not represent a habitat it is merely a convention. The process actually reduced the representation of some records within the dataset that consisted of irregular polygons of mapped habitat. In some cases the EO records do not adequately represent know populations. For example: the occurrence of *Zizania texana* on the San Marcos River is represented in the database as one occurrence with a 200 m diameter circle. In actuality it is considered one population of plants with 10 to 13 occurrences on an approximate 10 km length of the San Marcos River (Oxley 2006). This same issue surely occurs with a number of other records.

Preliminary analysis revealed that some of the more common species had a large impact on results due to lack of representation in the dataset rather than actual rarity. To insure that more common species did not overshadow rare species, G3, G4, S3, and S4—species known to have 20 to 200 populations—were included only if they had more than five records of occurrence. The processing of species assemblage data mimicked that of the G3/G4 species.

The resulting biodiversity records consisted of 52 elements including: 30 G1/G2/S1/S2 species and two G1/G2/S1/S2 species assemblages, 10 G3/G4/S3/S4 species and 10 species assemblages (Table 4.2). The list of biodiversity elements includes: 6 invertebrates, 12 amphibians, 4 fish, 3 birds, 2 animal assemblages, 15 vascular plants, and 10 vegetation classifications.

Environmental Data Processing

Environmental data were processed to create classes or types that could be used in the prioritization process following Sahotra et al. (2005). Geologic and Soils data came as categorical data. Inconsistencies with naming in the geologic files occurred between two rock types in Hays County. This is likely due to the mapping project being split up into segments completed at different times with different personnel. In the San Antonio data layer that covers the Southwestern portion of the study area Ked, Edwards limestone, in orange, intersects the Austin data layer that has Kfr, Fredricksburg group, in blue (Figure 2.2). Edwards limestone is descriptively part of the Fredricksburg group. Because the original data came with these names and no clear justification for how to change the data could be made, the discrepancy remained in the analysis. In addition, gaps in coverage between the Llano, Austin, and San Antonio data layers ranged from 0 to 10 m. To resolve this issue and insure no areas lacked geologic data, polygons were extended to meet each other.

Topographic data consisted of a digital elevation model (DEM) classified into ten elevation ranges at 50 m intervals, from 100 to 550m. The spatial analyst tool within ArcGIS 9.1 created both slope and aspect data layers (ESRI 2006). Slope values included 10 classes determined by default values in ArcGIS using Natural Jinks (Sarkar et al. 2005). Aspect included 10 classes at 30 degree increments, with one class for flat areas.

Table 4.2: Biodiversity Conservation Elements

The study used 52 biodiversity conservation elements in the systematic conservation planning process including: 30 G1/G2/S1/S2 species, 2 G1/G2/S1/S2 species assemblages, 10 G3/G4/S3/S4 species, and 10 additional species assemblages.

Rank	Scientific Name	Common Name	National Listing	Category
G1/G2/S1	Batrisodes texanus	Coffin Cave Mold Beetle	LE: Listed endangered	Invertabrate
G1/S1	Bufo houstonensis	Houston Toad	LE: Listed endangered	Amphibian
G2/S2	Charadrius montanus	Mountain Plover		Bird
G3/S2	Croton alabamensis var. texensis	Texabama Croton		Vascular Plant
G1/S1	Cylindropsis sp. 1	Tooth Cave Blind Rove Beetle		Invertabrate
G2/S2	Dendroica chrysoparia	Golden-cheeked Warbler	LE: Listed endangered	Bird
G1/S1	Etheostoma fonticola	Fountain Darter	LE: Listed endangered	Fish
G1/S1	Eurycea nana	San Marcos Salamander	LT: Listed threatened	Amphibian
G1/S1	Eurycea naufragia	Georgetown Salamander	C: Candidate	Amphibian
G2/S2	Eurycea pterophila	Blanco River Springs Salamander		Amphibian
G1/S1	Eurycea rathbuni	Texas Blind Salamander	LE: Listed endangered	Amphibian
G1/S1	Eurycea robusta	Blanco Blind Salamander		Amphibian
G1/S1	Eurycea sosorum	Barton Springs Salamander	LE: Listed endangered	Amphibian
G1/S1	Eurycea sp. 6	Pedernales River Springs Salamander		Amphibian
G1/S1	Eurycea tonkawae	Jollyville Plateau Salamander		Amphibian
G1/S1	Eurycea waterlooensis	Austin Blind Salamander	LE: Listed endangered	Amphibian
G2/S2	Hymenopappus carrizoanus	Sandhill Woolywhite		Vascular Plant
G1/G2/S1	Neoleptoneta myopica	Tooth Cave Spider	LE: Listed endangered	Vascular Plant
G2/S2	Notropis buccula	Smalleye Shiner	C: Candidate	Fish
G2/S2	Philadelphus ernestii	Canyon Mock-orange		Vascular Plant
G2/S2	Physostegia correllii	Correll's False Dragon-head		Vascular Plant
G5/S1	Rana pipiens	Northern Leopard Frog		Amphibian
G1G2/S1	Rhadine persephone	Tooth Cave Ground Beetle	LE: Listed endangered	Invertabrate
G2/S2	Schizachyrium scoparium-sorghastrum nutans series	Little Bluestem-indiangrass Series		Internatl. Vegetation Class
G4/S2	Sphagnum spp.-rhynchospora spp. series	Sphagnum-beakrush Series		Internatl. Vegetation Class
G2/S2	Streptanthus bracteatus	Bracted Twistflower		Vascular Plant
G1/G2/S1	Tartarocreagris texana	Tooth Cave Pseudoscorpion	LE: Listed endangered	Invertabrate
G2/G3/S1	Texamaurops reddelli	Kretschmarr Cave Mold Beetle	LE: Listed endangered	Invertabrate
G2/G3/S1	Texella reddelli	Bee Creek Cave Harvestman	LE: Listed endangered	Invertabrate
G2/G3/S1	Texella reyesi	Bone Cave Harvestman	LE: Listed endangered	Invertabrate
G2/G3/S2	Vireo atricapilla	Black-capped Vireo	LE: Listed endangered	Bird
G1/S1	Zizania texana	Texas Wild-rice	LE: Listed endangered	Vascular Plant
G3/S3	Amorpha roemeriana	Texas Amorpha		Vascular Plant
G3/S3	Berberis swaseyi	Texas Barberry		Vascular Plant

Table 4.2: Biodiversity Conservation Elements (continued)

Rank	Scientific Name	Common Name	National Listing	Category
G3/G4/S3	Epipactis gigantea	Giant Helleborine		Vascular Plant
G5/S3	Festuca versuta	Texas fescue		Vascular Plant
G4/S4	Gambusia geiseri	Largespring Gambusia		Fish
G3/S3	Hexalectris nitida	Glass Mountains Coral-root		Vascular Plant
G3/S3	Micropterus treculi	Guadalupe Bass		Fish
G3/S3	Onosmodium helleri	Heller's False-gromwell		Vascular Plant
G4/S4	Physaria engelmannii	Engelmann Bladderpod		Vascular Plant
G3/S3	Tridens buckleyanus	Buckley Tridens		Vascular Plant
	Colonial Waterbird Nesting Area	Colonial Waterbird Nesting Area		Animal Assemblage
	Invertebrate cave			Animal Assemblage
G4/S4	Juniperus ashei - Quercus (buckleyi, fusiformis, vaseyana, sinuata var. breviloba) woodland	Ashe's Juniper - (Buckley Oak, Plateau Live Oak, Vasey Shin Oak, White Shin Oak) Woodland		Internatl. Vegetation Class
S4	Pinus taeda - Quercus stellata / Crataegus spp. woodland	Loblolly Pine - Post Oak / Hawthorn Species Woodland		Internatl. Vegetation Class
	Prairie Remnant	Prairie Remnant		Internatl. Vegetation Class
G3/S3	Quercus buckleyi - Juniperus ashei - Fraxinus texensis forest	Buckley Oak - Ashe's Juniper - Texas Ash Forest		Internatl. Vegetation Class
G2/G3/S4	Ulmus crassifolia - Carya illinoinensis - Celtis laevigata / Chasmanthium sessiliflorum - carex cherokeensis forest	Cedar Elm - Pecan - Sugarberry / Longleaf Spikegrass - Cherokee Sedge Forest		Internatl. Vegetation Class
G2/G4/S3	Quercus fusiformis / Schizachyrium scoparium woodland	Plateau Live Oak / Little Bluestem Woodland		Internatl. Vegetation Class
G4/S4	Quercus stellata-Quercus marilandica series	Post Oak-blackjack Oak Series		Internatl. Vegetation Class
G2/S3	Taxodium distichum - Platanus occidentalis edwards plateau forest	Bald-cypress - Sycamore Edwards Plateau Forest		Internatl. Vegetation Class

Four climate data sets, following Sarkar et al. (2005), contributed to the prioritization process: annual precipitation, mean annual temperature, maximum average temperature in hottest month, and minimum average temperature in the coldest month. Temperature data included one degree classes, resulting in three classes for mean temperature (18 to 20°C), four classes for maximum temperature in hottest month (33 to 36°C), and three classes for the minimum temperature in the coldest month (1 to 3°C).

The annual precipitation included equal interval classes of 25 mm, resulting in eight classes (725 to 1,025 mm).

Water data consisted of four components: floodplain, Edwards Aquifer zones, critical water quality stream buffers, and watersheds. Critical water quality stream buffers and watersheds were created using ArcHydro (Maidment, Morehouse, and Grise 2002). This process involved the following steps: “burning” the streams into the DEM, filling any pits or missing data, determining flow direction, determining flow accumulation and drainage areas, and finally creating watersheds. Critical water quality buffers followed City of Austin standards for streams draining 640 acres or more by creating a 60.96 m (200’) buffer on each side of the stream (COA 2006). The stream buffers, combined with the 100-year floodplain, created the critical water quality areas used for analysis.

Created watersheds, delineated at 76 km^2, combined with existing City of Austin watershed layer, always preferring City of Austin data, created the 170 watersheds used in this study. It is worth noting that many of the urban watersheds in the City of Austin watershed layer are smaller than 76km^2 (COA 2006).

Land Use Data Evaluation and Processing

Habitat loss due to encroaching human activity is the dominant factor in decreasing biological and environmental diversity in the study area (Diamond, True, and He 1997; Johnston 1997). Vulnerability of areas to development is often looked at when evaluating the results of the prioritization process (Margules and Pressey 2000). This study incorporated vulnerability directly into the prioritization process using three datasets: county appraisal district parcel data from 2005, extra territorial jurisdictions, and a preferred development scenario from Envision Central Texas. Because there is no precedent for incorporating vulnerability into the prioritization process, all runs with vulnerability data were also run without vulnerability data.

The first land use data set preferred land parcels greater than twenty acres. Small parcels create a number of issues for management and limit the amount of biodiversity as well as ecological function. The lower limit of 20 acres was derived from the Texas Parks and Wildlife Department recommendation for the minimum allowable parcel size to qualify for the Wildlife Use Appraisal Evaluation Program in Central Texas

(Texas_Comptroller 2002). The second dataset associated proximity to city limits with higher vulnerability and risk of transformation. This layer used the extraterritorial jurisdictional boundaries (ETJs) of municipalities to define areas at high risk of transformation. In addition to vulnerability, ETJs are areas where municipalities have jurisdiction to enforce ordinances related to environmental protection, such as water quality, and the municipality can justify land acquisition for conservation. If ETJs were unavailable, a 1.61 km (1 mile) buffer was created around the city limits. The final land use dataset took the inverse of future development Scenario D from Envision Central Texas to form preferred conservation areas (ECT 2004).

ENVIRONMENTAL SPACE EVALUATION

Choosing and understanding data is an important part of conservation planning. To understand how environmental variables within the study area changed with respect to biodiversity records and open space, select environmental variables were graphed pair-wise in environmental space (Austin 1998; Austin and Heyligers 1989; Peralvo, Sierra, and Young 2006). The following combinations were looked at in detail: average annual temperature vs. average annual precipitation, elevation vs. average annual precipitation, and elevation vs. average annual temperature. The resulting graphs display the relationship of the environmental variables in the study area as a whole, in open space, and at biodiversity record locations.

To evaluate the study area in environmental space, values for all environmental variables were acquired at 30,000 random points within the study area using the extract to points tool in ArcGIS 9.1. In addition to these locations, points were created within open space areas and biodiversity records to ensure representation of these areas in the graphs. The extracted data were graphed in three series: study area, open space, and biodiversity records. The graphs allowed qualitative assessment of the relationship between these variables. The methodology was repeated for select solution sets to evaluate increases of representation in environmental space as a result of the prioritization process.

Evaluation Units and Probabilities

Place prioritization requires the use of an evaluation unit to make comparisons between areas. The shape, size and point of origin of evaluation units can affect results. Preliminary prioritization runs addressed three questions: 1) does the size of the evaluation unit matter? 2) Are watersheds a better unit for evaluation than square grid cells? And 3) Does the point of origin of the grid system, thereby determining the location of borders between evaluation units, have any effect on solution sets? The preliminary runs used cells ranging in size from 10,000 m^2 to 25 km^2. They included both square cells and watersheds, and they used only biodiversity records as conservation elements. Grid cells were created using the Fishnet Extension and watersheds were created using the Archhydro tool, both in ArcGIS 9.1.

In all cases the solution set is smaller—more efficient with respect to area—with reductions in size of the evaluation units. Larger cells were easy to use but produced irrelevant results due to their size. Smaller cells created smaller solution sets but, if too small, also created two problems: computational complexity and lack of ecological relevancy. As the cells get smaller the complexity of the calculations rises substantially, resulting in prioritizations taking days to complete. With respect to ecological relevancy, the smallest cell used, 100 m by 100 m, was actually smaller than the biodiversity records that were 200 m diameter circles. This resulted in a fragmentation of the dataset and did not allow for the overlap of occurrences that makes complementarity a useful conservation planning tool.

Watershed catchments and grid cell evaluation included size comparisons from 0.76 km^2 to 25 km^2. In all cases grid cells resulted in smaller solution sets than watersheds. Grid cells prioritized areas on average 41% more efficiently, with respect to total area, than watersheds for all reasonable scenarios evaluated. In addition, the use of watersheds is substantially more time and computationally intensive than using grid cells.

Finally, concern over the ambiguity of establishing a point of origin from which to create grid cells prompted the evaluation of a 1 km grid cell network. The grid cells were shifted five times, each time 100 meters east, thereby resulting in six sets of evaluation units. Prioritization runs conducted with the six evaluation unit grids showed a 6% deviation in size of solution sets which would substantially decrease with a reduced cell size making the origin of the grid cells a non-issue.

This study primarily used 500 m by 500 m grid cells to allow for efficiency in solution sets, computational flexibility, and a reasonable implementation size. The use of a UTM grid followed many European conservation plans (Williams, Margules, and Hilbert 2002). The extent of evaluation units covered the border of the areas captured within the 2005 county appraisal records and within 1.5 km of the county boundary. This process resulted in the creation of 45,745 cells (11,436.25 km^2).

The intersection of evaluation units with conservation elements determined the areas of occurrence of each element in each cell using the tabulate to area tool in ArcGIS 9.1. The resulting cross tab file included a column to represent every conservation element and a row to represent every evaluation unit. To allow for this data to be used in ResNet, they were converted to an expectation of occurrence – ranging from 0 to 1 with 1 meaning a conservation element is found in 100% of the evaluation unit. Following Sarkar et al. (2004) this number can be thought of as a probability of occurrence for a particular conservation element in that evaluation unit.

Portions of the study area have been either transformed or are currently in some type of conservation management. To assure that areas in conservation are accounted for in the prioritization process an initialization set was created. The initialization set consisted of evaluation units that contained 50% or more of preserve or state park land—1,088 evaluation units (272 km^2, 2.48% of the study area). While it is a conservative assumption that biodiversity and ecological services are only conserved in these areas, the management plans of other open space parcels are unknown and therefore could not be included.

A great deal of the study area has already been transformed by human use, will not be set aside for conservation in the foreseeable future, and should not be considered for conservation prioritization. The criterion for excluding an evaluation unit from the prioritization process was that more than 50% of its area contained parcels of less than twenty acres defined by the 2005 county appraisal files (CAPCOG 2006). As a result 8,877 cells (2,219.25 km^2) were considered transformed, leaving an evaluation area used in the prioritization process of 36,868 cells (9,217 km^2).

TARGET SETTING

For this study, a target is the desired percentage of the total area of occurrence of a conservation element to be included in the solution set. Targets varied from one prioritization run to the next to evaluate the effect of different conservation elements. Determination of targets encompassed the entire study area including transformed areas. This ensures that the levels of occurrence take into account a conservation elements previous distribution in what are now transformed areas in evaluating the importance of its remaining distribution in untransformed areas.

Following Sarakinos et al. (2001), rare biodiversity records—those with G1/G2/S1/S2 rankings—had higher target levels at 50 to 100%. G3/G4 species targets varied from 12 to 50% with most runs using a target level of 12 or 20%. Species assemblage targets varied from 0 to 12%. Geology, soil, topographic, climate, vulnerability, and water resource targets ranged from 0 to 40%.

Forty prioritization runs showed a range of potential conservation priority areas. Each of the runs had a target set (TS) which is a list of the targets for each of the conservation elements (Table 5.1). The study included 330 conservation elements in 17 categories. Each target set has a target percentage for each of the categories. For example, TS-16 appears as the following in Table 5.1: 80min-12-0-0-12-12-12-12-5-5-5-20-20-12-12-12-5. The numbers, in order, represent the percentage target for the conservation elements in the following categories:

1. G1/G2 species and species assemblage (count: 32),
2. G3/G4 species (count: 10),
3. Species assemblages from NPAT (count: 1),
4. Species assemblages from Texas Heritage Database (count: 7),
5. Topography (elevation (10 classes), slope (10 classes), and aspect (10 classes)),
6. Soil (28 types),
7. Geology (47 types),
8. Climate (average annual precipitation (8 classes) average. annual temperature (3 classes), average cold temperature in coldest month (3 classes), avgerage warmest temperature in hottest month (3 classes)),

9. Land use (preferred conservation area (1 class)),
10. Land use (parcels greater than 20 acres (1 class)),
11. Land use (extra territorial jurisdictions (1 class)),
12. Critical water quality areas including floodplains (1 class),
13. Edwards aquifer recharge zone (1 class),
14. Edwards aquifer contributing zone (1 class).
15. Edwards aquifer transition zone (1 class),
16. Edwards aquifer contributing zone in the transition zone (1 class), and
17. Watersheds (count: 170).

PRIORITIZATION PROCESS

Prioritization of areas took place through a step-wise process based on the concepts of complementarity in the ResNet software program (Aggarwal 2000). Inputs for the process included the following files in a text format: a cross-tabulated data file with the expectation of occurence for each conservation element in each cell, a target set, and the initialization set of cells already in conservation. The target files contained an index number and individual target level for each of the 330 conservation elements.

ResNet used complementarity and rarity to prioritize sites based on the target levels for each of the forty runs. The Dos version Res_RC was used in this study. Using complementarity, the evaluation unit containing the most conservation elements not meeting their targets was added to the solution set. This process continued until all conservation elements met their target levels.

SOLUTION SET ANALYSIS

A solution set includes all prioritized areas resulting from one run of the systematic conservation planning process based on a particular target set. Solution sets were evaluated for total area, spatial patterns, representation of biodiversity records, irreplaceability, representation in environmental space, and feasibility. Spatial patterns were evaluated with two measures: 1) A simple measure of cells in common by intersecting two solution sets, and 2) The Hamming Distance, a measure of spatial likeness. The Hamming Distance measures the union of two spatial areas minus the intersection, divided by the sum of the two areas: (A U B)- (A int B)/ (Area A + Area B) (Sarkar et al. 2005). Environmental space graphs displayed the environmental variable and biodiversity record representation achieved by solution sets. Irreplaceability was evaluated as a simple measure of the reoccurrence of evaluation units in multiple solution sets. These evaluation measures showed areas that are of high conservation value using a number of target sets and demonstrated a range of conservation scenarios.

CHAPTER 5: RESULTS

This study evaluated conservation priorities under a number of different scenarios using biodiversity, environmental, and land use data. The study area was analyzed through environmental space graphs that showed the relationship of biodiversity records, existing open space, and proposed conservation lands. Using systematic conservation planning, forty prioritization runs resulted in the addition of 21.25 to 2,323.25 km² (5,250 to 5,738,590 acres) in conservation lands. Each run used different conservation element targets, which in turn altered the conservation priorities. Runs are divided into the following categories: prioritizations using only species data, baseline evaluation of environmental variables, prioritizations using combinations of conservation elements with base environmental target levels of 5%, 12%, and 20%, prioritizations using only environmental variables, and prioritizations including species assemblages. The runs are evaluated here based on their total area, spatial patterns, representation of conservation elements, use of lexical order, feasibility, and representation in environmental space. Five solution sets are explained in greater detail for their general distributions and their ability to meet multiple open space needs. An irreplaceability measure was used to highlight areas prioritized under multiple conservation scenarios. All results should be evaluated in greater detail for inclusion in conservation lands.

ENVIRONMENTAL SPACE

Environmental space looks at the range of environmental variable combinations in an area. Pair-wise analysis of environmental variables within this study shows the relationship of those variables to existing open space and biodiversity records. The three combinations of environmental variables looked at in detail are: average annual precipitation vs. elevation, elevation vs. average annual temperature, and average annual temperature vs. average annual precipitation (Figures 5.1 through 5.3). It is important to remember when viewing these graphs that areas that appear close in the graphs are not necessarily close in geographic space.

The environmental space graphs show good representation of biodiversity and environmental diversity in western Travis County. This representation is due to the multiple conservation programs that have conserved land for biodiversity and water quality in the area. The graphs show a lack of environmental representation in areas with moderate precipitation and high elevation—western Hays County—and areas with moderate rainfall, precipitation and temperature—eastern Williamson County, portions of Bastrop County, and Caldwell County.

Average Annual Temperature Compared to Elevation

Average annual temperature vs. elevation shows a regular inverse relationship between the two variables. As areas decline in elevation they increase in average annual temperature (Figure 5.1). Open space shows good coverage in the core of the environmental space with gaps on the periphery. An obvious gap in environmental space that is surrounded by open space ranges from 19.0 to 19.5°C and 175 to 200 m elevation. Looking at geographic space, this gap represents a portion of the Blackland Prairie in Williamson County. Biodiversity records occur with temperature and elevation values found within existing open space with few exceptions. Occurences of *Pinus taeda-Quercus stellata/ Crategus spp*. woodland at 19.7 to 19.8°C and 100 to 130 m elevation are not represented in open space. This is also true for occurrences of *Epipactic gigantean* at 19.1°C and 215 to 230 m elevation. This graph shows that existing open space represents the areas around and to the west of Austin but lacks representation in the Blackland Prairie and Post Oak Savannah.

Average Annual Precipitation Compared to Elevation

Average annual precipitation vs. elevation does not show a regular pattern between the two variables (Figure 5.2). The areas with the highest rainfall are at the lowest elevations, at mid-elevations there is less variability in precipitation, and at higher elevations the precipitation levels rise and expand in range. At 207 m elevation and from 770 to 800 mm precipitation there is a strong demarcation to no representation in environmental space due to the existence of Lake Travis.

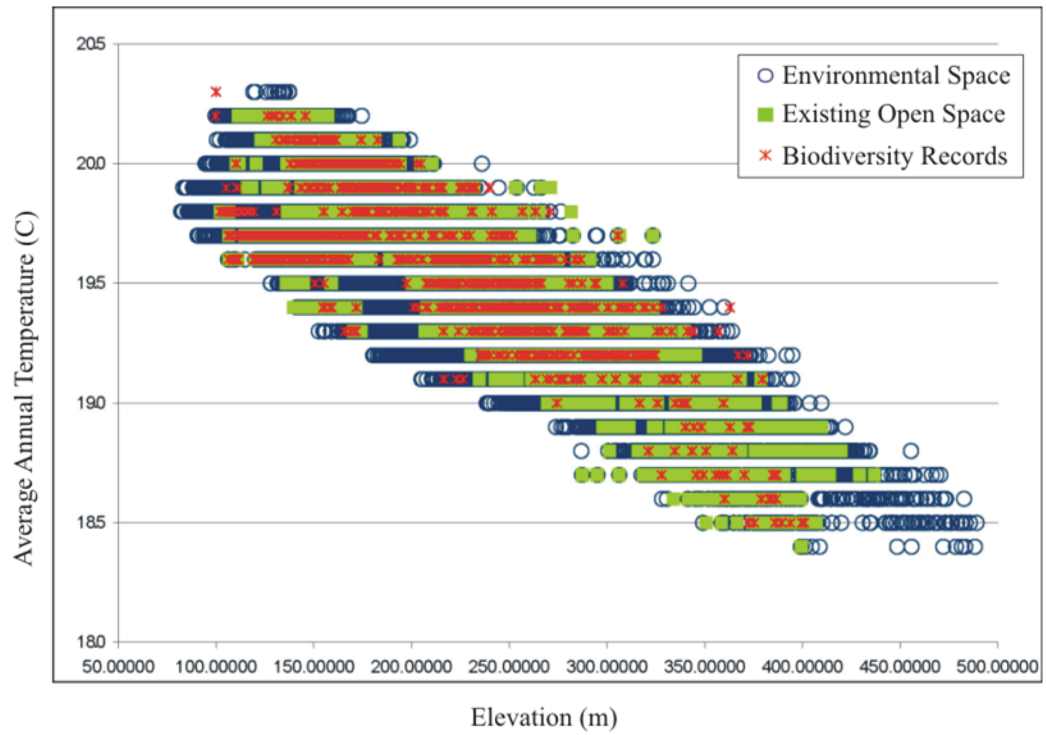


Figure 5.1 Environmental Space Graph: Average Annual Temperature vs. Elevation

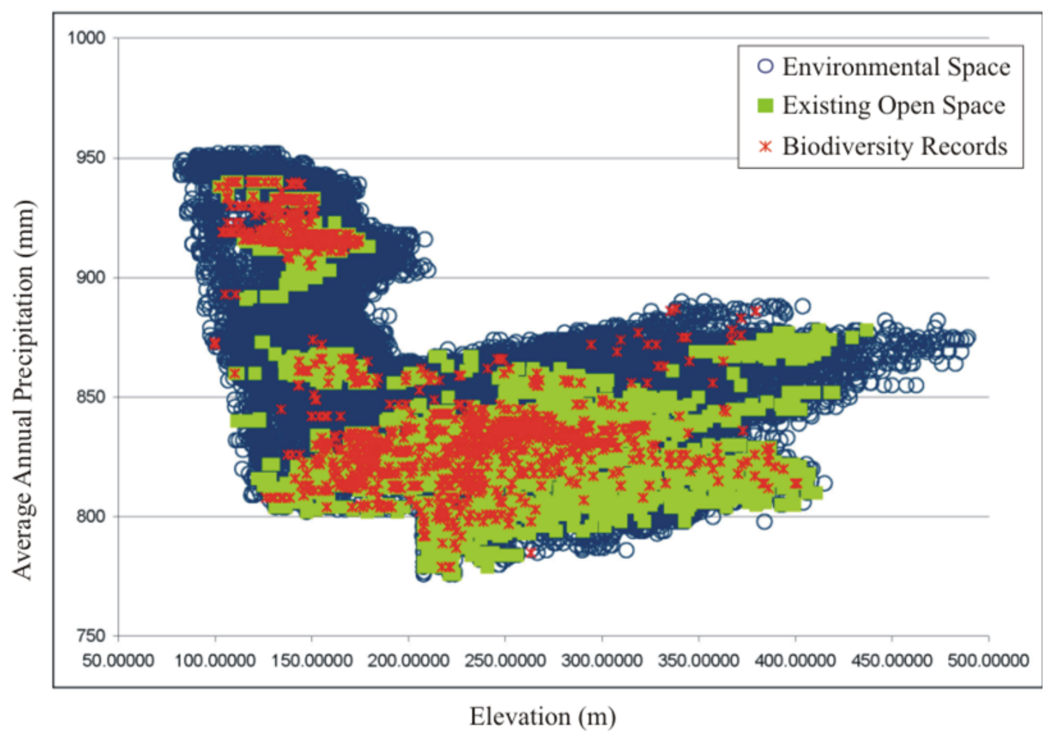


Figure 5.2 Environmental Space Graph: Average Annual Precipitation vs. Elevation

Open space has four clusters when comparing precipitation and elevation. The "Lost Pines" area in Bastrop County is the open space cluster with high rainfalls (880 to 940 mm) and low elevations (100 to 180 m). Granger Lake, in northeast Williamson County, is below the lost pines, with moderate rainfall (855 to 875 mm) and low elevations (120 to 180 m). Storm Ranch is the third open space cluster with moderate rainfall (860 to 875 mm) and high elevations (340 to 435 m). The final open space cluster is by far the largest and includes most of the remaining open space that centers on areas west of Austin with low to moderate precipitation levels and the entire midrange of elevation values. Using the open space areas as markers, there is substantial lack of representation of environmental variables around Lost Pines, Granger Lake, and Storm Ranch. This confirms what was seen in Figure 5.1, portions of the Blackland Prairie and Post Oak Savannah, as well as portions of the Edwards Plateau in southwest Hays County are in need of conservation.

Using Figure 5.2, biodiversity records are well represented in open space with some exceptions. Exceptions include four prairie remnants in the Cotton Creek Watershed with precipitation from 840 to 850 mm and elevations from 145 to 165 m. There are a number of unrepresented biodiversity records in southern and western Hays County with precipitation levels from 850 to 890 mm and 290 to 380 m elevation: *Juniperus ashei-Quercus* woodlands, *Quercus fusiformis / Schizachyrium scoparium* woodlands, *Dendroica chrysoparia*, *Hexalectris nitida*, and *Physaria engelmannii*. This lack of representation of biodiversity records is consistent with the need for conservation lands in southern and western Hays County and eastern portions of the study area.

Average Annual Precipitation Compared to Average Annual Temperature

Average annual precipitation vs. average annual temperature showed distinct patterns throughout the study area. There is a large temperature range at higher precipitation levels from 900 to 950 mm and 19.5 to 20.3°C. In addition, there are two trailing areas of lower temperatures from 18.4 to 18.9°C (Figure 5.3). Four areas of biodiversity records are not well represented in open space. They include a moderate temperature (19.1 to 19.5°C) and moderate rainfall (860 to 890 mm) zone in southern and

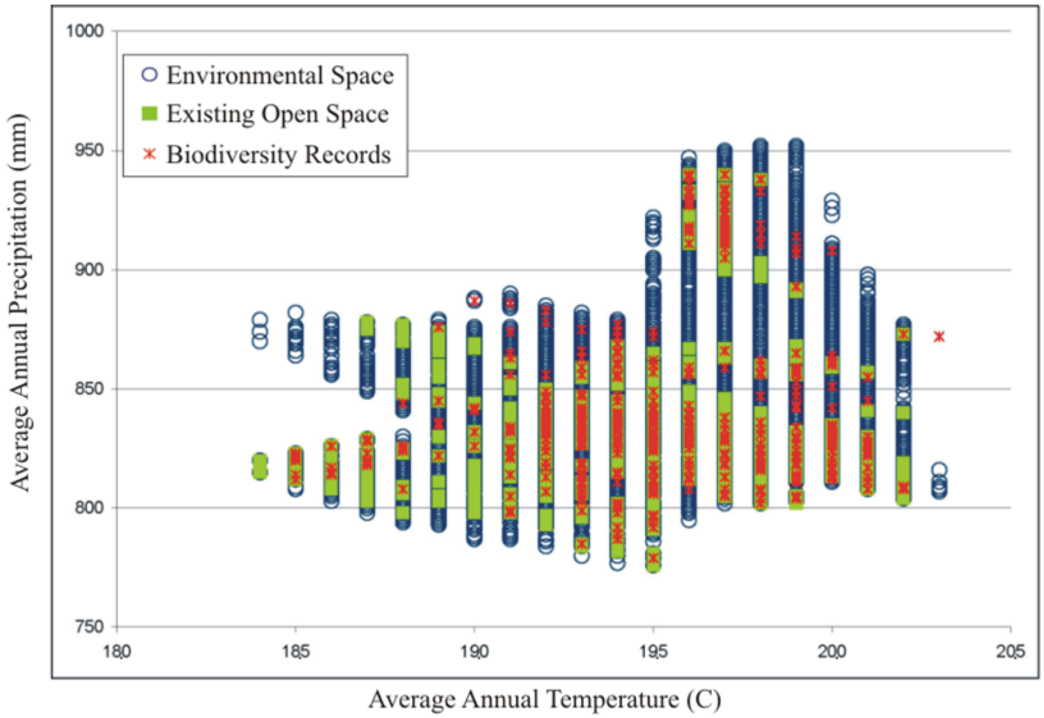


Figure 5.3 Environmental Space Graph: Average Annual Precipitation vs. Average Annual Temperature

western Hays County. This area includes the species identified in Figure 5.2 with the addition of *Berberis swaseyi* and *Festuca versuta*. At the same precipitation and temperature levels in northeastern Williamson County there are a number of prairie remnants. In eastern Bastrop and Caldwell Counties biodiversity records occurred outside of open space with high temperatures (19.8 to 20.0°C) and high rainfall (905 to 920 mm) including: *Helianthus occidentalis ssp. plantagineus*, *Rhododon ciliatus*, *Hymenopappus carrizoanus*, and *Pinus taeda-Quercus stellata/ crategus spp*. woodlands. Finally, two disparate areas: the prairie remnants already mentioned along Cottonwood Creek, and a group of species in central Caldwell County are outsides open space at rainfall and temperature levels ranging from 838 to 855 mm and 19.8 to 20.0°C. Biodiversity records in this area include: *Quercus fusiformis / Schizachyrium scoparium* woodlands, *Ulmus crassifolia – Carya illinoinensis – Celtis laevigata / Chasmanthium sessiliflorum-Carex cherokeensis* forest, *Quercus buckleyi – Juniperus ashei – Craxinus texensis* forest, *Schizachyrium scoparium-sorghastrum nutans* series, and a colonial waterbird nesting area.

The evaluation of openspace in this graph shows that open space is represented at lower precipitations and throughout the temperature range. In the moderate precipitation levels from 860 to 900 mm there is almost no open space. The area, a strip running through eastern Williamson County to the southern tip of Caldwell County, is the same portion of the study area seen in Figure 5.1. The comparison of precipitation vs. temperature confirms the need for additional conservation lands in southern and western Hays, eastern Williamson, Bastrop, and Caldwell Counties.

PRIORITIZATION RUNS

Systematic conservation planning showed conservation priorities for the study area under a variety of scenarios. Forty prioritization runs using the ResNet software resulted in solution sets that added from 21.25 to 2,323.25 km^2 (5,250 to 5,738,590 acres) in conservation lands (Table 5.1). This is equivalent to 0.19% to 20.44% of the total study area. The prioritization runs are broken down into the following categories: prioritizations using only species data, baseline evaluation of environmental variables, prioritizations using combinations of conservation elements with base environmental target levels of 5%, 12%, and 20%, prioritizations using only environmental variables, and prioritizations including species assemblages. This approach allows for an understanding of the influence of different conservation elements on the resulting solution sets. Solution sets are discussed in general terms and in categories. Five solution sets are looked at in greater detail: TS-5, TS-6, TS-11, TS-40, and TS-25.

Prioritizations Using Only Biodiversity Records

Biodiversity is a primary motivator of conservation and has resulted in substantial lands dedicated to conservation within the study area. To understand the influence of biodiversity on solution sets the first group of prioritizations, TS-1 through TS-4, used only biodiversity records. These target sets, even with target levels of 80% for G1/G2 species, resulted in minimal increases in total area added in conservation lands, ranging from 21.25 to 56.5 km^2—0.19 to 0.49% of the study area. These percentages show that each of the biodiversity elements included in this study could have representation in conservation lands with minimal increases in conservation lands.

An example solution set with only biodiversity from TS-1 prioritized areas primarily in the three western Counties. In Hays County, prioritized areas are located in the southwest portion of the county, downtown San Marcos, and around Wimberley. In Williamson County there are a number of sites around Lake Georgetown and sites containing numerous karst features. At the boarder of Williamson and Travis Counties on Robinson Ranch in the Lake Creek and the Brushy Creek Watersheds there are a number of prioritized areas. A large portion of the solution set, 125 of the 225 cells outside of the initialization set, are in Travis County. This preponderance is partly due to the high biodiversity levels of the Edwards Plateau and partly due to increased surveying mandated as a result of more development pressure. Similar patterns are seen in TS-2, TS-3, and TS-4 with relatively few cells differentiating solution sets. These sites should be included in conservation lands. In particular, the sites in Williamson and Hays Counties should be included for protection in the regional habitat conservation plans currently being created in each county.

Baseline Evaluation of Environmental Variables

A number of environmental variables are used as conservation elements in this study. To get a basic understanding of their impact on solution sets, target sets TS-5 and TS-6 used only environmental variables with no biodiversity variables at 5% and 12% target levels (only 5% for development variables). These runs resulted in additional conservation areas of 453 and 1,188.25 km^2— 3.98% and 10.45% of the study area, respectively (Figures 5.4 and 5.5). Of the 1,812 cells prioritized by TS-5, 106 are at least partially within existing open space, 230 are at least partially within the recharge zone, and 927 are at least partially within the CWQA. Of the 4,753 cells chosen by TS-6, 211 are at least partially within existing open space, 562 are at least partially within the recharge zone, and 2,778 are at least partially within the CWQA. This baseline analysis of environmental variables shows that the inclusion of multiple variables distributes the solution set throughout the study area. In addition, it shows that with less than a 4% addition of conservation lands there can be substantial environmental diversity representation.

Table 5.1: Target Sets and Resulting Prioritization Areas

Target Set	Target levels (%)	# of Cells	# of Cells Outside Initialization Set	Total Area (sq km)	Total Area Added (sq km)	% of Total Area (includes intialization area)	% of Total Area Added	# of Cells Chosen by Lexical Order	% Chosen by Lexical Order	Irreplaceability
1	80-50	1,312	225	328.00	56.25	2.87	0.49			N
2	80min-50	1,313	226	328.25	56.50	2.87	0.50			N
3	80min-12	1,297	210	324.25	52.50	2.84	0.46			N
4	50-12	1,172	85	293.00	21.25	2.56	0.19			N
5	0-0-0-0-5-5-5-5-5-5-5-5-5-5-5-5-5	2,899	1,812	724.75	453.00	6.34	3.98	763	42.11	N
6	0-0-0-0-12-12-12-12-5-5-5-12-12-12-12-12-12	5,840	4,753	1,460.00	1,188.25	12.77	10.45	1,836	38.63	N
7	80min-12-0-0-5-5-5-5-0-0-0-0-0-0-0-0-0	2,729	1,642	682.25	410.50	5.97	3.61	855	52.07	N
8	80min-12-0-0-5-5-5-5-5-0-0-0-5-5-5-5-5-0	2,718	1,631	679.50	407.75	5.94	3.59	672	41.20	Y
9	80min-12-0-0-5-5-5-5-5-5-5-5-5-5-5-5-5	3,001	1,914	750.25	478.50	6.56	4.21			Y
10	80min-12-0-0-5-5-5-5-5-5-5-20-5-5-5-5-5	3,339	2,252	834.75	563.00	7.30	4.95			Y
11	80min-12-0-0-5-5-5-5-5-5-5-20-20-5-5-5-5	3,705	2,618	926.25	654.50	8.10	5.76	372	14.21	Y
12	80min-12-0-0-5-5-5-5-5-5-5-40-40-5-5-5-5	5,977	4,890	1,494.25	1,222.50	13.07	10.75			Y
13	80min-12-0-0-12-12-12-12-0-0-0-0-0-0-0-0-0	5,880	4,793	1,470.00	1,198.25	12.85	10.54	3,027	63.15	N
14	80min-12-0-0-12-12-12-12-5-5-5-12-12-12-12-12-0	5,906	4,819	1,476.50	1,204.75	12.91	10.60			Y
15	80min-12-0-0-12-12-12-12-5-5-5-12-12-12-12-12-5	5,859	4,772	1,464.75	1,193.00	12.81	10.49	2,626	55.03	Y
16	80min-12-0-0-12-12-12-12-5-5-5-20-20-12-12-12-5	6,130	5,043	1,532.50	1,260.75	13.40	11.09			Y
17	80min-20-0-0-12-12-12-12-5-5-5-40-40-5-20-5-5	7,879	6,792	1,969.75	1,698.00	20.00	14.94			Y
18	80min-12-0-0-20-20-20-20-0-0-0-0-0-0-0-0-0	9,837	8,750	2,459.25	2,187.50	21.50	19.24	5,648	64.55	N
19	80min-12-0-0-20-20-20-20-0-0-0-20-0-0-0-0-0	9,682	8,595	2,420.50	2,148.75	21.17	18.90	3,366	39.16	Y
20	80min-12-0-0-20-20-20-20-0-0-0-20-20-0-0-0-0	9,681	8,594	2,420.25	2,148.50	21.16	18.90			Y
21	80min-20-0-0-20-20-20-20-5-5-5-12-12-12-12-12-5	9,519	8,432	2,379.75	2,108.00	20.81	18.54			Y
22	80min-20-0-0-20-20-20-20-0-0-0-12-12-12-12-12-0	9,753	8,666	2,438.25	2,166.50	21.32	19.06	4,630	53.43	Y
23	80min-20-0-0-20-20-20-20-12-12-12-40-20-20-20-20-20	9,595	8,508	2,398.75	2,127.00	20.97	18.71	1,229	14.45	Y
24	80min-20-0-0-20-20-20-20-12-12-12-40-40-20-20-20-20	10,380	9,293	2,595.00	2,323.25	22.69	20.44			Y
25	80min-20-0-0-20-20-20-20-5-5-5-40-40-20-20-20-5	10,285	9,198	2,571.25	2,299.50	22.48	20.23	1,483	16.12	Y

Table 5.1: Target Sets and Resulting Prioritization Areas (continued)

Target Set	Target levels (%)	# of Cells	# of Cells Outside Initialization Set	Total Area (sq km)	Total Area Added (sq km)	% of Total Area (includes intialization area)	% of Total Area Added	# of Cells Chosen by Lexical Order	% Chosen by Lexical Order	Irreplaceability
26	80min-20-0-0-20-20-20-20-0-0-0-40-40-20-20-20-0	10,322	9,235	2,580.50	2,308.75	22.56	20.31			Y
27	80min-20-0-0-20-20-20-20-5-5-5-40-40-20-20-20-0	10,339	9,252	2,584.75	2,313.00	22.60	20.35			Y
28	80min-20-0-0-20-20-20-20-0-0-0-20-20-20-20-20-12	9,525	8,438	2,381.25	2,109.50	20.82	18.56			Y
29	0-0-0-0-20-20-20-20-12-12-12-40-20-20-20-20-12	9,435	8,348	2,358.75	2,087.00	20.63	18.36			Y
30	0-0-0-0-20-20-20-20-12-12-12-40-40-20-20-20-12	10,209	9,122	2,552.25	2,280.50	22.32	20.06			Y
31	0-0-0-0-20-20-20-20-5-5-5-40-40-20-20-20-5	10,285	9,198	2,571.25	2,299.50	22.48	20.23			Y
32	0-0-0-0-20-20-20-20-5-5-5-40-40-20-20-20-0	10,345	9,258	2,586.25	2,314.50	22.61	20.36			Y
33	80min-12-12-0-12-12-12-12-5-5-5-12-12-12-12-12-5	5,856	4,769	1,464.00	1,192.25	12.80	10.49			Y
34	80min-12-0-12-12-12-12-12-5-5-5-12-12-12-12-12-5	5,859	4,772	1,464.75	1,193.00	12.81	10.49			Y
35	80min-12-12-12-12-12-12-12-5-5-5-12-12-12-12-12-12	5,923	4,836	1,480.75	1,209.00	12.95	10.63			Y
36	80min-12-12-12-12-12-12-12-5-5-5-12-12-12-12-12-5	5,856	4,769	1,464.00	1,192.25	12.80	10.49			Y
37	80min-12-12-12-12-12-12-12-5-5-5-20-20-12-12-12-5	6,127	5,040	1,531.75	1,260.00	13.39	11.08			Y
38	80min-20-12-12-12-12-12-12-5-5-5-20-20-12-12-12-5	6,127	5,040	1,531.75	1,260.00	13.39	11.08			Y
39	80min-20-12-12-12-12-12-12-0-0-0-20-20-12-12-12-5	6,138	5,051	1,534.50	1,262.75	13.42	11.11			Y
40	80min-20-12-12-12-12-12-12-5-5-5-20-20-12-12-12-0	6,175	5,088	1,543.75	1,272.00	13.50	11.19	1,342	26.38	Y

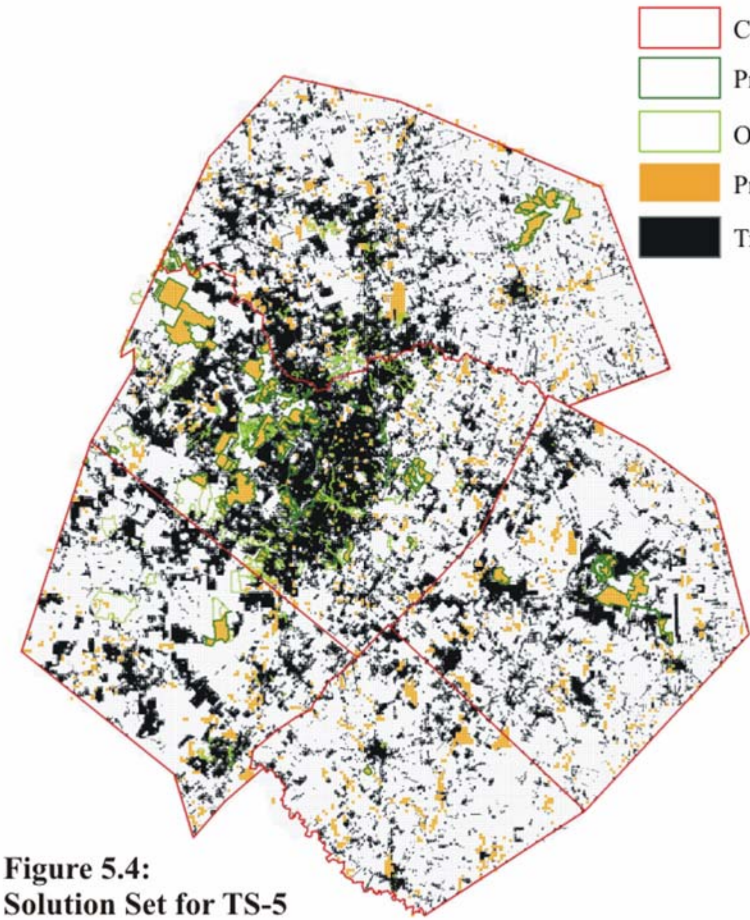


Figure 5.4:
Solution Set for TS-5

TS-5 used environmental and vulnerability variables at 5% target levels with no biodiversity variables. The solution set adds 4% of study area in conservation lands.

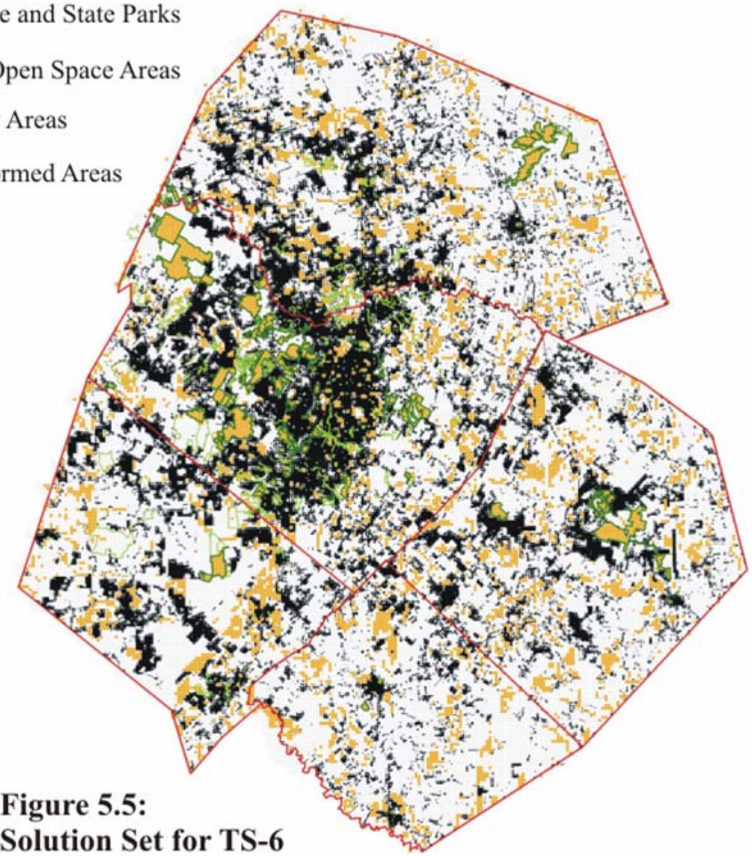


Figure 5.5:
Solution Set for TS-6

TS-6 used environmental variables at 12% and vulnerability variables at 5% with no biodiversity variables. The solution set adds 10% of the study area in conservation lands.

Prioritizations Using Combinations of Conservation Elements

The next set of runs used a combination of biodiversity records and environmental variables as conservation elements. Each run varied target levels for conservation elements that resulted in changes in pattern and size of the solution sets. The variation among solution sets clearly shows that there is not one "right" answer for conservation priorities. Conservation priorities are a function of the goals and data. This highlights the importance of a quantifiable and transparent process for conservation planning.

Environmental Variables at 5% Target Levels

The first runs to combine biodiversity and environmental variables kept basic environmental variables for topography, substrate, and climate data at 5% target levels. The resulting solution sets added 407.75 to 1,222.5 km² to conservation areas—3.59 % to 10.75% of the study area. Using 5% target levels for water variables in TS-8 resulted in a 2.75 km² decrease in the size of the solution set as compared to TS-7. It is surprising that the addition of more conservation elements led to a smaller overall size of the solution set. This issue is repeated throughout the prioritizations and investigated further below by analyzing the use of lexical order in the area selection process. TS-9 further dispersed its solution set across the study area with the addition of vulnerability and watershed variables. Comparing the solution set for TS-7 to that of TS-9, the two solution sets have 807 cells in common out of 1,829 (44%) outside of the initialization set. The hamming distance between the two solution sets is .3854. These measurements of spatial likeness show that the addition of water, watershed, and vulnerability variables significantly changes the shape and pattern of conservation priorities. This can be compared to TS-10 and TS-11 that vary only by an increase in the recharge zone target from 5 to 10%. The hamming distance for these two solution sets is .2032 with 1,940 cells in common out of 2,930 outside the initialization set (66%). There are still significant differences between these two solution sets but the difference in pattern is not as great as that seen by the initial addition of variables.

Target sets TS-7 through TS-12 used a combination of biodiversity and environmental variables and showed a variety of spatial patterns in their solution sets. The general pattern showed that the addition of more conservation elements resulted in more dispersed solution sets. TS-11, an example solution set, contains a number of areas in critical water quality areas and the recharge zone reflecting the high target levels of 20% for those variables (Figure 5.6). Of the 2,618 cells chosen by TS-11, 2,176 are at least partially within the CWQA, 853 are at least partially within the recharge zone, and 295 are at least partially within existing open space. These solution sets show the importance of carefully selecting conservation elements as the addition or omission of variables can greatly change the spatial patterns found in solution sets.

Environmental Variables at 12% Target Levels

The next group of runs moved the environmental variables for topography, substrate, and climate to 12%. These target sets, TS-13 to TS-17, resulted in solution sets that added 1,193 to 1,260.75 km² to conservation areas—10.49 to 14.94% of the study area. As with the 5% target sets, adding additional conservation elements actually reduced the overall area needed to meet targets in some cases. TS-15, with development and watershed variables at 5%, and water variables at 12%, had a solution set 5.25 km² smaller than TS-13. This pattern, as seen when comparing TS-7 and TS-8, is surprising in that a solution set should not get smaller with the addition of more conservation elements. The hamming distance between TS-13 and TS-15 is .4427 and the target sets have 2,665 cells in common out of 6,900 (39%). This shows that the two solution sets have substantially different spatial patterns. These solution sets confirm the change in spatial pattern as result of the addition of water and vulnerability layers.

Environmental Variables at 20% Target Levels

This collection of runs increased the basic environmental variable target levels for target sets TS-18 to TS-28. Target level for topography, substrate, and climate variables were raised to 20% while changing water, development, and watershed variables for each target set. The resulting solution sets added 2,108 to 2,323.25 km² to conservation areas—18.56 to 20.44% of the study area. Again the addition of more conservation elements resulted in smaller solution sets. TS-18 had a larger solution set than TS-19, TS-20, TS-21, TS-22, TS-23, or TS-28. Comparing TS-18 to TS-21, the hamming distance is .4485 and they have 4,738 in common of 12,444 outside of the initialization set (38.1%).

The solution set for TS-25 shows a preference for the recharge zone and the CWQA, reflecting their high target levels of 40% (Figure 5.7). This target set has one of the largest areas added to conservation areas at 2,300 km². Of the 9,198 cells added to the solution set, TS-25 contains 626 at least partially in existing open space, 1,815 at least partially in the recharge zone, and 6,755 at least partially within the CWQA. These results affirm the patterns seen in other runs that the inclusion of water and vulnerability variables distributes the prioritized areas throughout the study area and significantly alter the spatial patterns of solution sets.

Prioritizations Using Only Environmental Variables

The next prioritization runs used only environmental variables. This was done for two reasons: 1) the vast majority of areas in the solution sets result from environmental variables, and 2) to test the ability of environmental variables to act as surrogates for the biodiversity data. A major justification for using environmental variables in conservation planning is their potential ability to represent biodiversity records (Sarkar et al. 2004; Garson, Aggarwal, and Sarkar 2002). By using only environmental variables as targets and analyzing the representation of biodiversity records in the solution set, this analysis showed the capability of the particular environmental variables used in this study to represent biodiversity records.

The number of biodiversity records included in each solution set was compared to equivalent runs that used targets for biodiversity records (Table 5.2). The area added to conservation lands for TS-29 through TS-33 ranged from 2,087 to 2,315 km²—18.36 to 20.36% of the study area. The four runs without biodiversity records contained from 44 to 51% of the cells with biodiversity records when including the initializing set. This representation alone would suggest that environmental variables are surrogates for biodiversity records. However, when evaluating only the cells added by the solution sets, the percentages dropped to 18 to 27%. These percentages are equivalent to the portion of the study area each of the solution sets occupied with a slight increase in representation of the biodiversity records for solution sets that had higher target levels for critical water

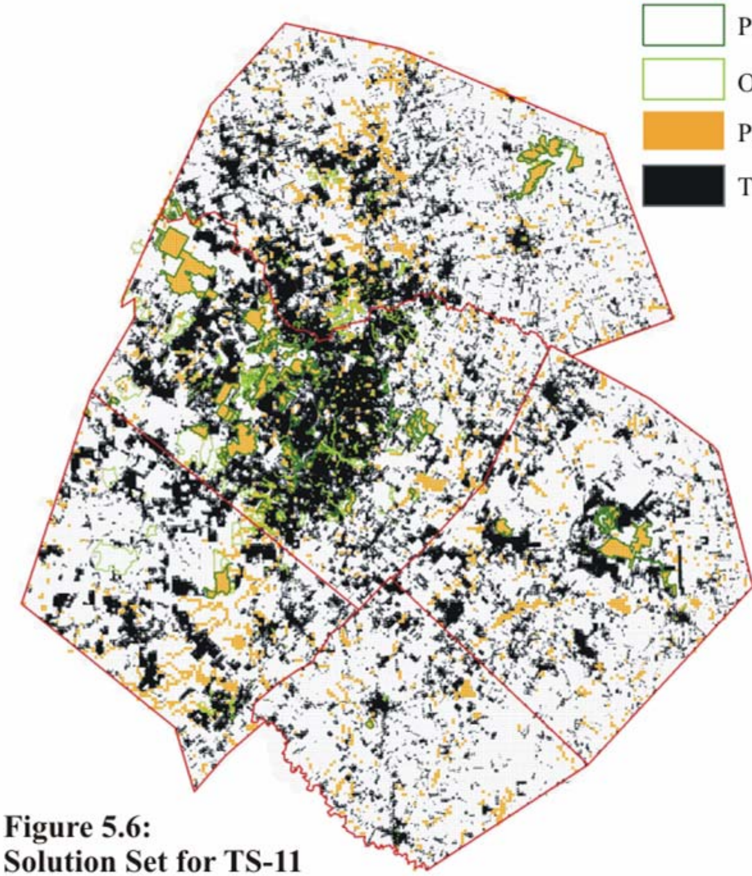


Figure 5.6:
Solution Set for TS-11

TS-11 prioritized rare biodiversity records at 80%, most environmental and vulnerability variables at 5%, and CWQA and recharge zone at 20%. The solution set adds 5.76% of the study area in conservation lands with a number of the areas aligning with stream networks, especially in the recharge zone.

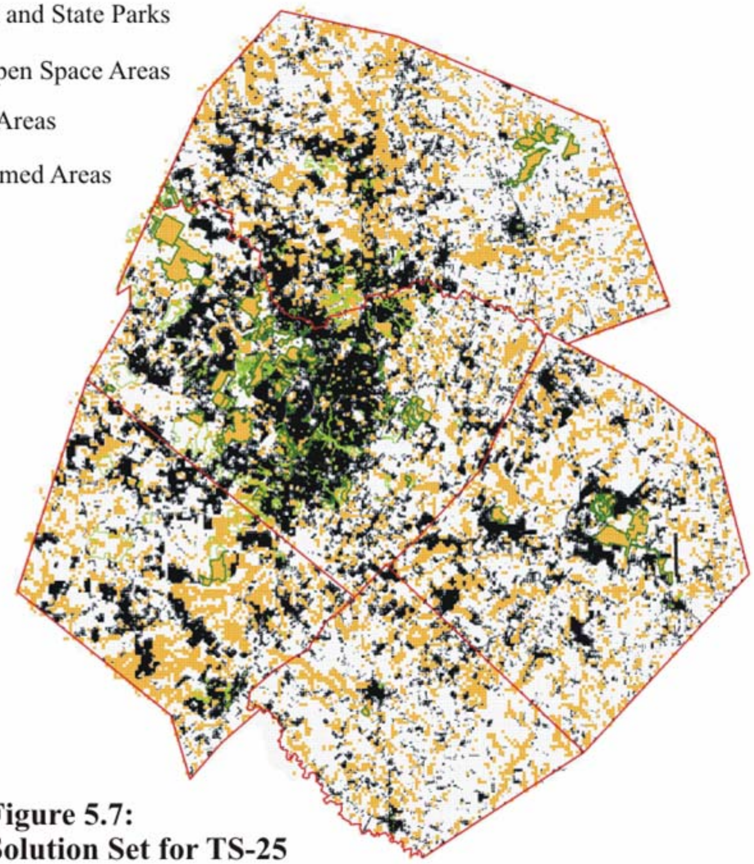


Figure 5.7:
Solution Set for TS-25

TS-25 prioritized rare biodiversity records at 80%, most environmental variables at 20%, vulnerability and watershed variables at 5%, and CWQA and recharge zone at 40%. The solution set adds 20.23% of the study area in conservation lands with substantial coverage throughout the study area especially along waterways and in the recharge zone.

Table 5.2: Representation of Biodiversity Records by Other Conservation Elements

	Target Set	Targets	# of Cells with Biodiversity Record	% of all Cells with Biodiversity Records	# of Cells with Biodiversity Records outide Intialization Set	% of Cells with Biodiversity Records outide Intialization Set	Solution Set Total Area as % of Study Area
Runs without Biodiversity Records	29	0-0-0-0-20-20-20-20-12-12-12-40-20-20-20-20-12	205	43.9	58	18.1	18.36
	30	0-0-0-0-20-20-20-20-12-12-12-40-40-20-20-20-12	220	47.1	73	22.8	20.06
	31	0-0-0-0-20-20-20-20-5-5-5-40-40-20-20-20-5	236	50.5	89	27.8	20.23
	32	0-0-0-0-20-20-20-20-5-5-5-40-40-20-20-20-0	236	50.5	89	27.8	20.36
Runs with Biodiversity Records	23	80min-20-0-0-20-20-20-20-12-12-12-40-20-20-20-20-20	385	82.4	238	74.4	18.71
	24	80min-20-0-0-20-20-20-20-12-12-12-40-40-20-20-20-20	391	83.7	244	76.3	20.44
	25	80min-20-0-0-20-20-20-20-5-5-5-40-40-20-20-20-5	389	83.3	242	75.6	20.23
	27	80min-20-0-0-20-20-20-20-5-5-5-40-40-20-20-20-0	392	83.9	245	76.6	20.35
Runs with only Biodiversity Records	1	80-50	372	79.7	225	70.3	0.49
	2	80min-50	373	79.9	226	70.6	0.50
	3	80min-12	357	76.4	210	65.6	0.46
	4	50-12	232	49.7	85	26.6	0.19

quality areas and the Edwards Aquifer Recharge Zone. This suggests that environmental variables are little better at selecting biodiversity records than random selection of evaluation units. That said, the environmental variables are contiguous over the entire study area while the biodiversity records are relatively localized, the biodiversity database is inadequate, the environmental variable targets were not altered for biodiversity preferences, and a number of existing biodiversity records were already in the initialization set. This analysis does suggest caution should be taken when assuming environmental variables will represent biodiversity records.

Prioritizations Including Species Assemblages

This group of prioritization runs focuses on the incorporation of species assemblages into the prioritization process and compares the total area of these runs to equivalent runs without assemblages. Species assemblage that did not have a ranking of G1/G2 were not used for most target sets because their characteristics and records are not as well defined as those of species. Considering the overall lack of data, and the general principle to make the best use of available data, assemblages demonstrated usefulness in TS-33 through TS-40. These solution sets added from 1,192.25 to 1,272 km^2 in conservation area —10.49 to 11.19% of the study area. Comparing TS-33, TS-34, and TS-36, each adding a different combination of assemblage, with TS-15—an equivalent target set without assemblages, the inclusion of assemblages affected solution set size by less than 1 km^2. An example solution set, TS-40, added 5,088 evaluation units to conservation lands and has a similar pattern to that of TS-11. TS-40 contains 3,297 cells at least partially in the CWQA, 868 cells at least partially in the recharge zone, and 305 cells at least partially in existing open space (Figure 5.8). This suggests that the inclusion of assemblages does not increase conservation costs and allowed the inclusion of more conservation elements in the solution sets.

LEXICAL ORDER EVALUATION

In order to better understand why some solution sets with fewer conservation elements had a larger total area, the use of lexical order was evaluated. Lexical order (the

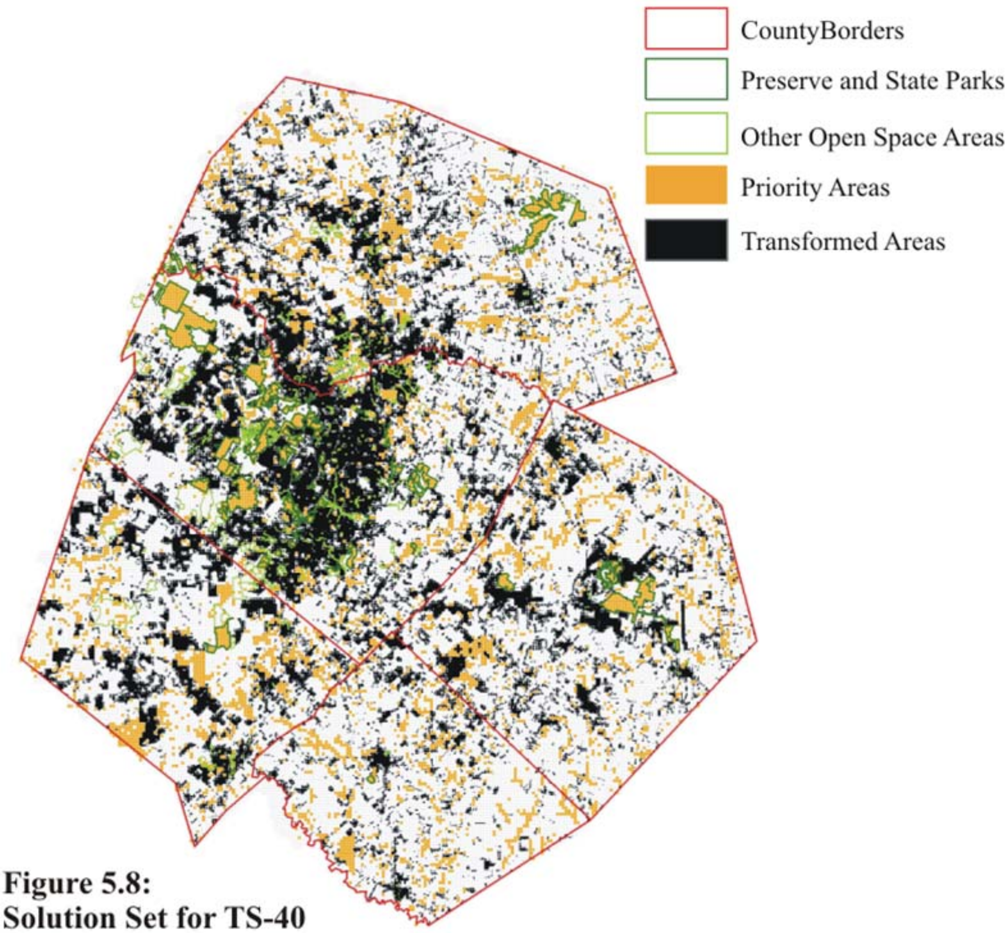


Figure 5.8:
Solution Set for TS-40
TS-40 prioritized species assemblages at 12%, rare biodiversity records at 80%, most environmental variables at 12%, vulnerability variables at 5%, CWQA and Edwards Aquifer recharge zone at 20%, and does not use watersheds. The solution set adds 11.19% in conservation lands and shows that assemblages can be included in the solution set with almost no increase in overall size of the solution set.

index order of evaluation units) is used to determine the area to be added if two or more cells contribute the same amount of targets to the solution set—it is the tiebreaker. This does not mean the selection of areas is arbitrary. Lexical order is used after complementarity has been calculated for each evaluation unit and more than one evaluation unit has the same complementarity value.

Cells were chosen by lexical order more often with target sets having fewer conservation elements (Table 5.1). For instance, the ResNet program used lexical order 52% of the time in the solution set for TS-7 as compared to 41% and 14% for TS-8 and

TS-11, respectively. This same pattern is seen between TS-13 and TS-15, and again with TS-18 as compared with a number of other target sets. This pattern suggests that the algorithmic process that defaults to lexical order may contribute to some of the inefficiencies in solution sets with fewer conservation elements. This finding should be investigated further as there is no rational in the systematic conservation planning literature that suggests a solution set should decrease in size with additional conservation elements.

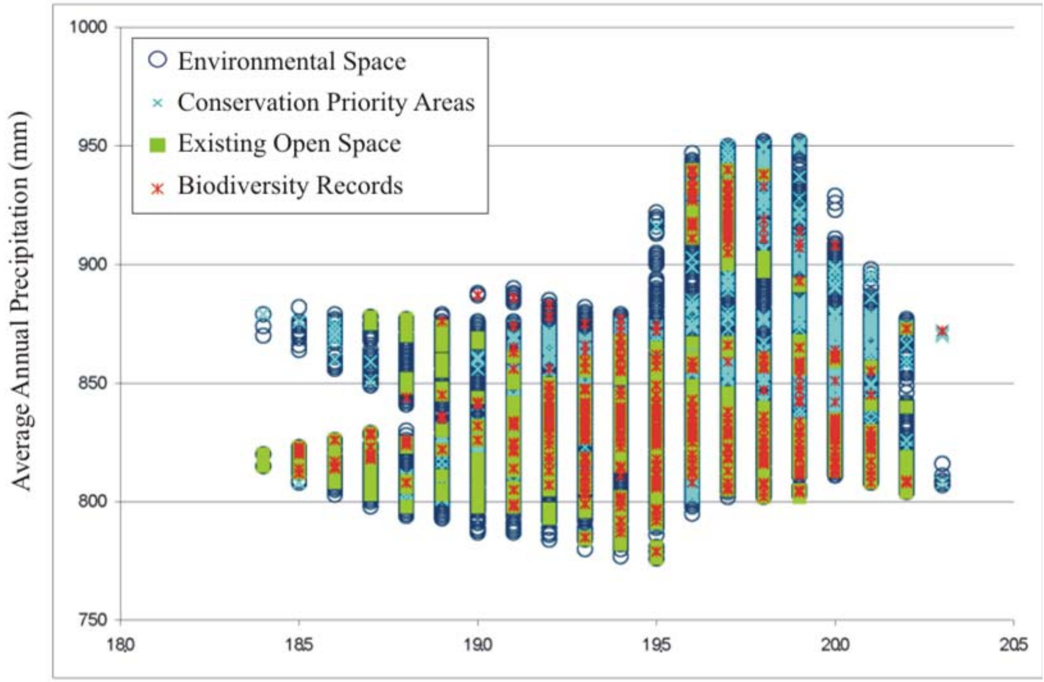
ENVIRONMENTAL SPACE ANALYSIS OF SOLUTION SETS

Environmental space graphs served as an analysis tool for select solution sets to understand their representation of environmental space and biodiversity records. Solution sets for TS-5, TS-6, TS-11, TS-25, and TS-40 were evaluated in environmental space using elevation vs. average annual precipitation and average annual precipitation vs. average annual temperature (Figures 5.9 through 5.13). All solution sets showed substantially greater representation of biodiversity records and environmental space than existing open space. Trends in the graphs show that with higher target levels there is greater representation, but this representation plateaus, suggesting there is less benefit of the highest target levels when looking solely at representation. This analysis again demonstrated the power of environmental space graphs as a visualization tool by showing the additional representation of environmental and biodiversity records in solution sets and further explaining the advantages of additional conservation lands.

The coverage of target sets TS-5 and TS-11 in environmental space show substantial gains in the representation of environmental variables and biodiversity records in prioritized sites. Both solutions show coverage of the gaps observed in the initial environmental space analysis in the eastern two thirds of the study areas, as well as areas in southwest Hays County. There is still, however, some lack of representation in both solution sets with TS-11 doing a better job of including biodiversity records. This analysis shows that the addition of 4% of the study area in conservation lands can substantially increase the inclusion of biodiversity and environmental diversity in open space.

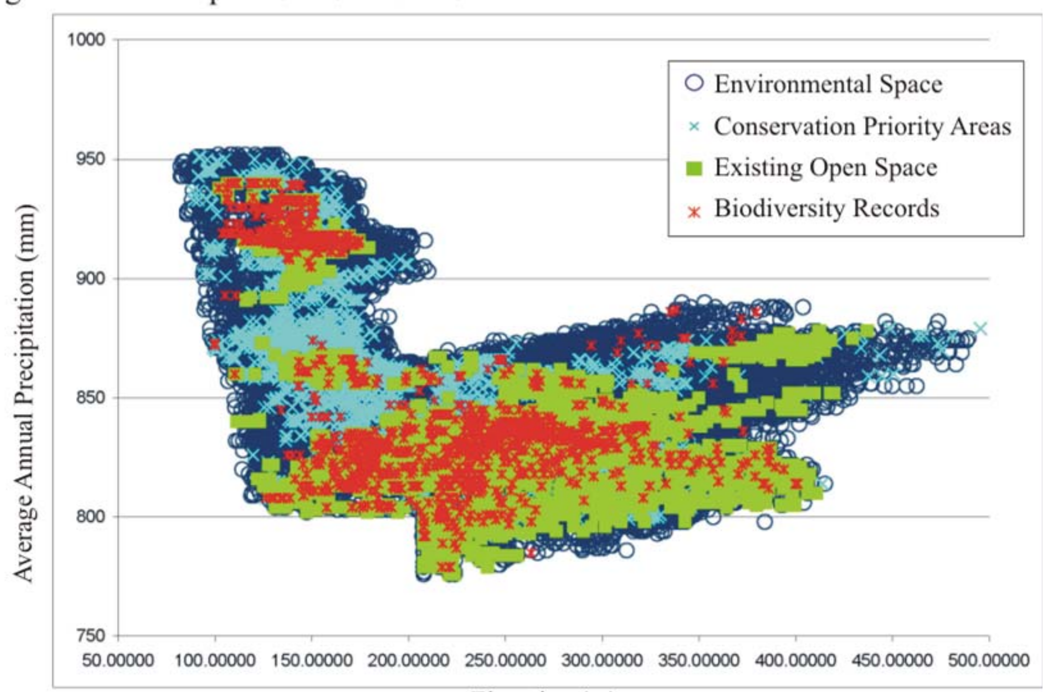
TS-25, which adds an additional 2,230 km² to conservation lands—equivalent to 20% of the study area, shows almost ubiquitous coverage in environmental space. This suggests that an additional 20% of the study area in conservation lands insures that all conservation elements would have at least partial protections. The coverage of TS-25, from a qualitative perspective, does not appear to be much more substantial than that found with TS-40 that adds 1,272 km² to conservation lands. This suggests that there is a threshold between 11% and 20% increases in conservation lands at which point there is diminishing increases in representation of environmental variables for further increases in conservation lands. Comparing the environmental space coverage of TS-40 to TS-6, TS-40 does a better job of representing biodiversity records. From the graphs it is hard to discern which solution set has greater coverage of environmental space. In all cases environmental space graphs confirm that the solution sets are incorporating biodiversity records and environmental variables into prioritized areas.

A) Average Annual Precipitation vs. Average Annual Temperature



Average Annual Temperature (C)

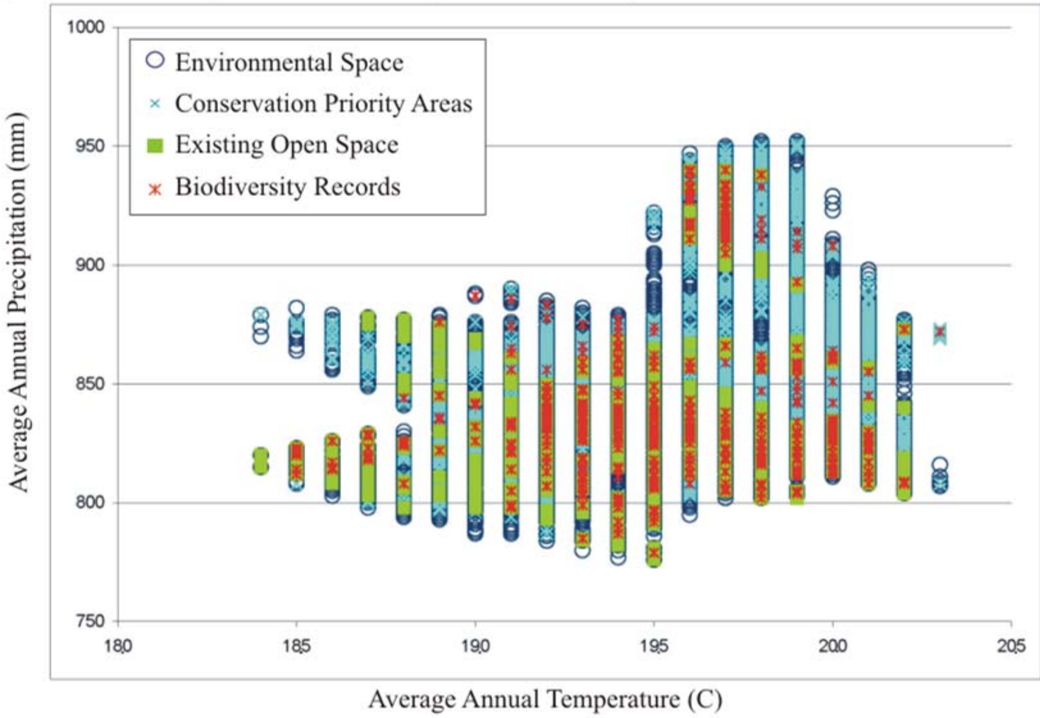
B) Average Annual Precipitation vs. Elevation



Elevation (m)

Figure 5.9 Environmental Space Graph of the Solutions Set for TS-5.
TS-5 prioritized environmental and vulnerability variables at 5% target levels and did not include biodiversity variables. The solution set shows increases in representation with a number of biodiversity areas lacking representation.

A) Average Annual Precipitation vs. Average Annual Temperature



B) Average Annual Precipitation vs. Elevation

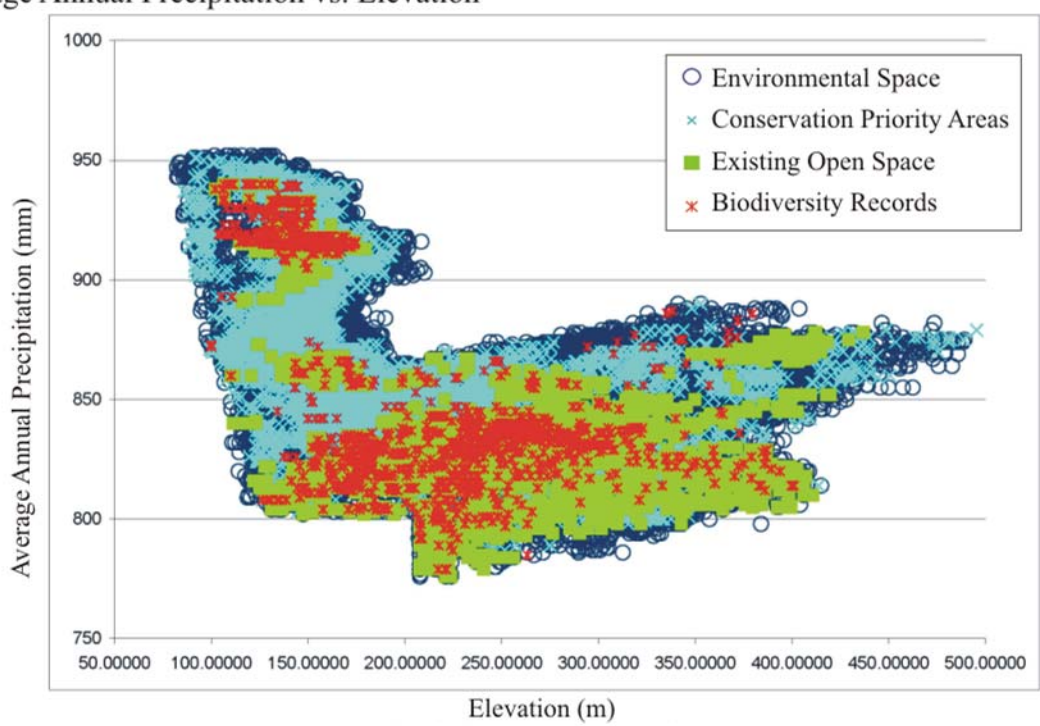


Figure 5.10 Environmental Space Graph of the Solution Set for TS-6.
TS-6 prioritized environmental variables at 12%, vulnerability variables at 5%, and did not include biodiversity variables. The solution set shows substantial increases in representation with some biodiversity records lacking representation.

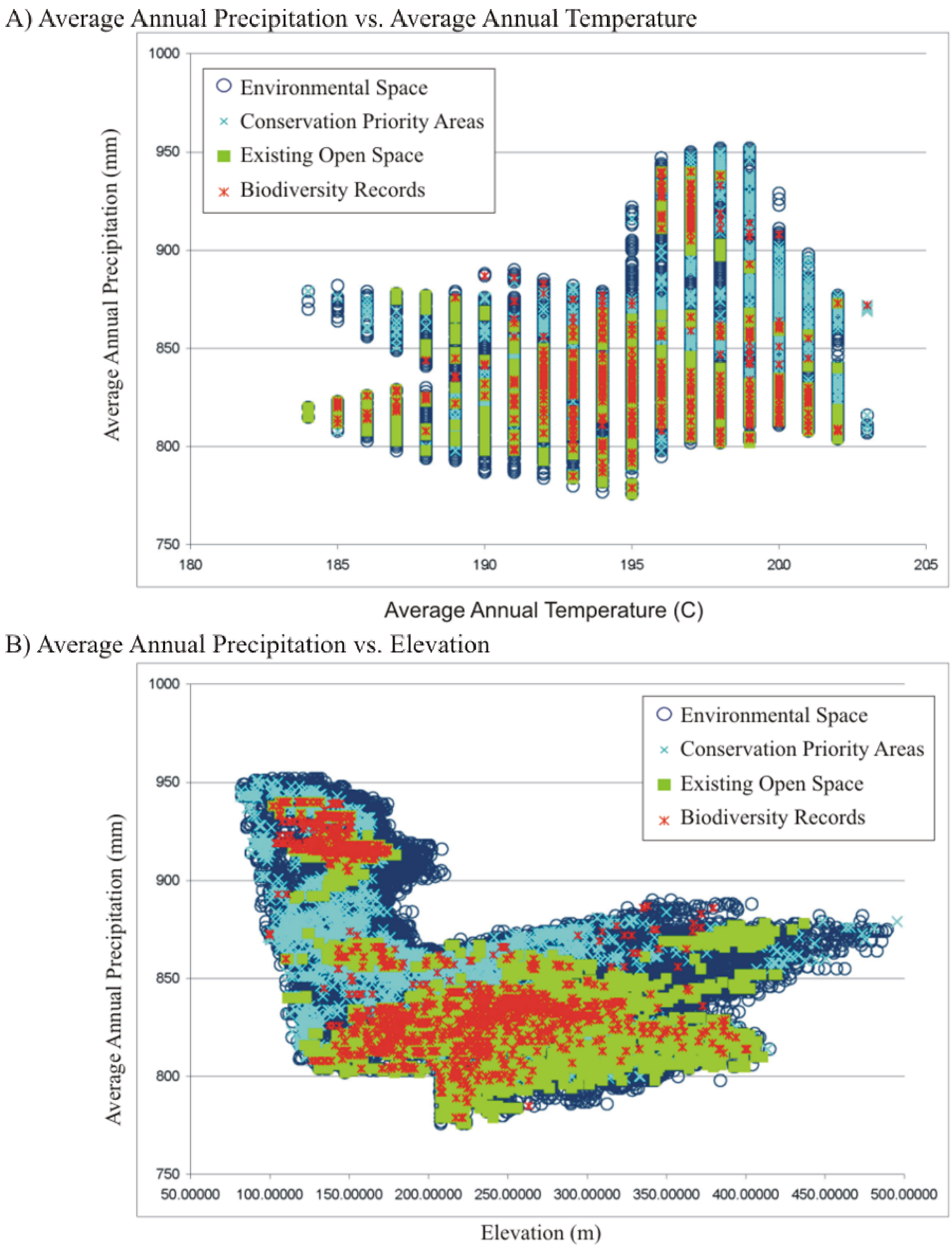
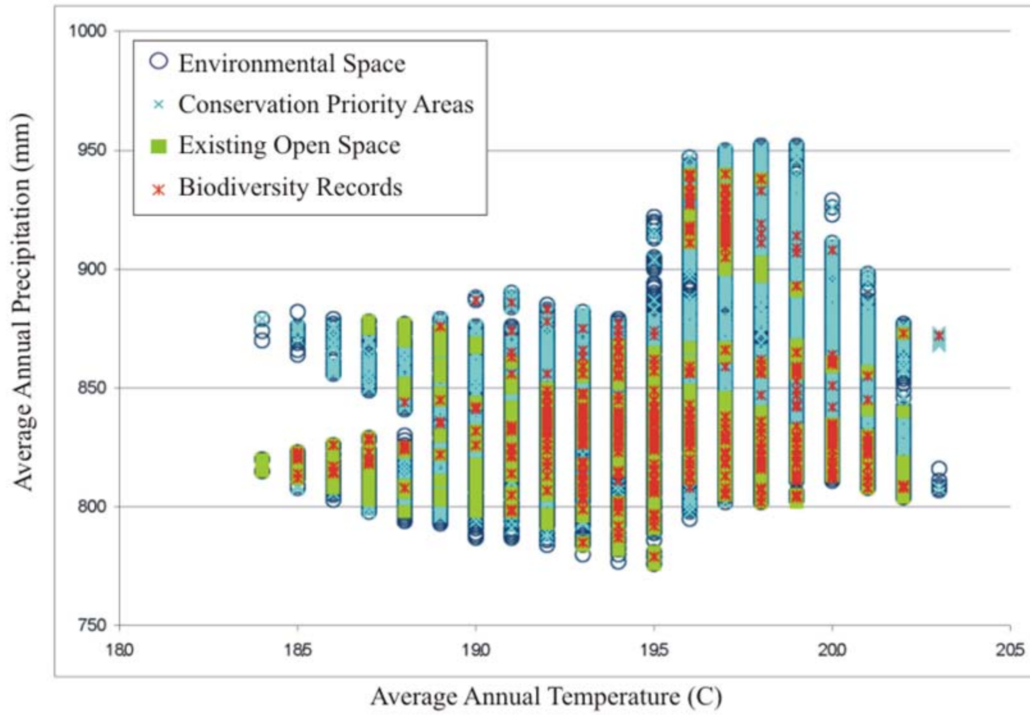


Figure 5.11 Environmental Space Graph of the Solution Set for TS-11.
TS-11 prioritized rare biodiversity variables at 80%, environmental variables at 5%, vulnerability variables at 5%, and CWQA and recharge zone at 20%. The solution set shows substantial increases in representation with some biodiversity records lacking representation.

A) Average Annual Precipitation vs. Average Annual Temperature



B) Average Annual Precipitation vs. Elevation

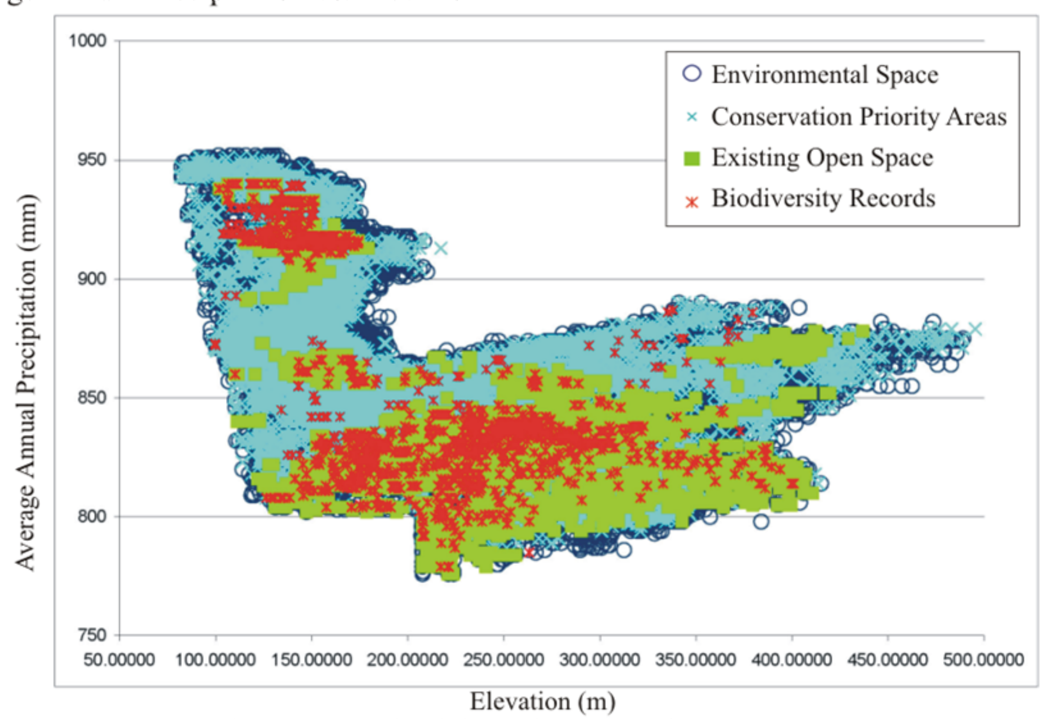
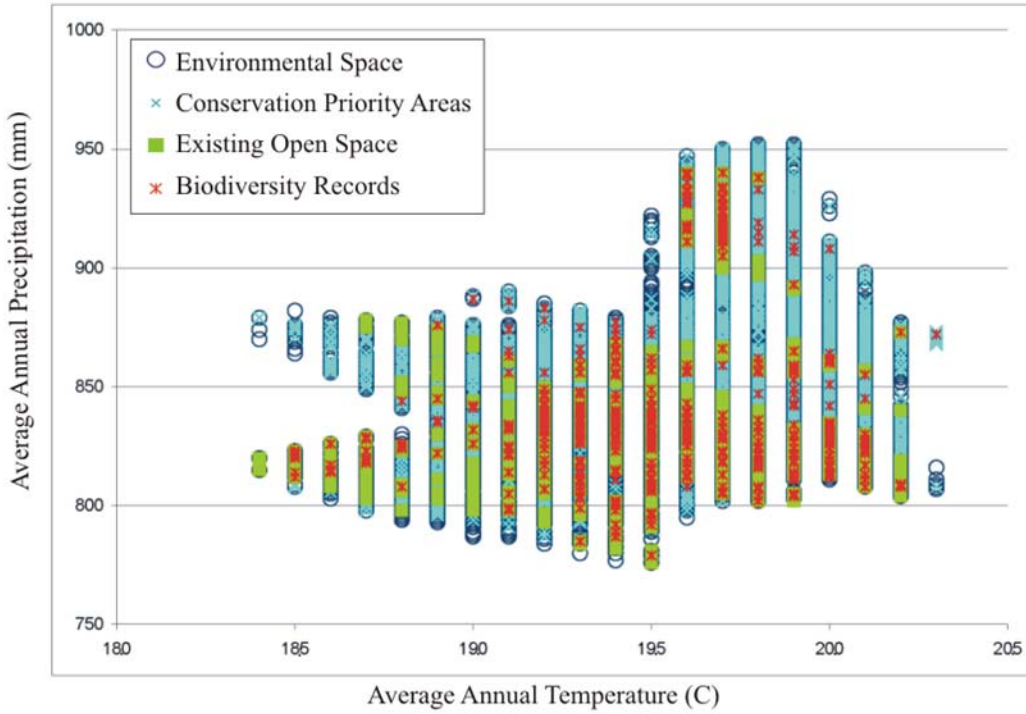


Figure 5.12 Environmental Space Graph of the Solution Set for TS-25.
TS-25 prioritized rare biodiversity at 80%, environmental variables at 20%, vulnerability variables at 5%, and CWQA and recharge zone at 40%. The solution set shows almost ubiquitous representation of environmental space.

A) Average Annual Precipitation vs. Average Annual Temperature



B) Average Annual Precipitation vs. Elevation

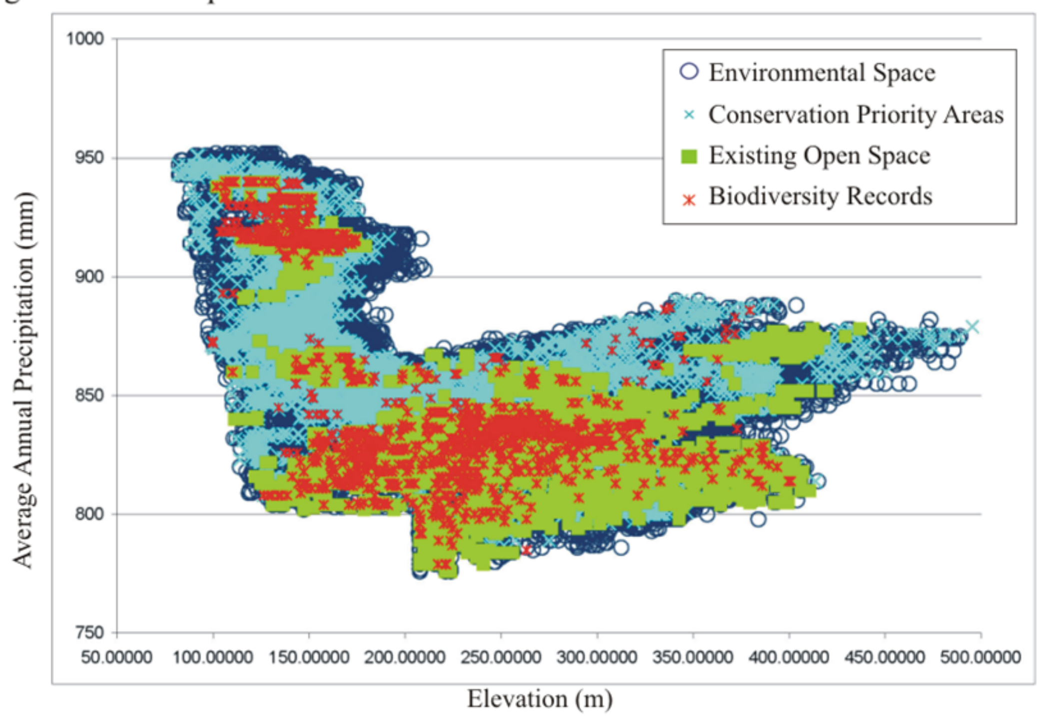


Figure 5.13 Environmental Space Graph of the Solution Set for TS-40.

TS-40 prioritized species assemblages at 12%, rare biodiversity at 80%, environmental variables at 12%, vulnerability variables at 5%, and CWQA and recharge zone at 20%. The solution set shows substantial representation of environmental space and biodiversity records.

IRREPLACEABILITY

An irreplaceability measure highlighted areas that were prioritized under multiple scenarios for conservation. The irreplaceability value measured the reoccurrence of evaluation units over 31 prioritization runs identified in Table 5.1 and shown in Figure 5.14. For this study, Irreplaceability is simply the percent of times an evaluation unit is included in the 31 solution set evaluated. All areas with an irreplaceability value of 75% or greater are listed in the Appendix with UTM and geographic coordinates to ensure that they can be found in the field. The entire list includes 1,391 evaluation units. Of these, 102 had an irreplaceability score of 100%, 26 of which had a biodiversity record. The other 81 units should be investigated in further detail. A general review of the location of these cells and their potential importance is listed below using both environmental and geographic space.

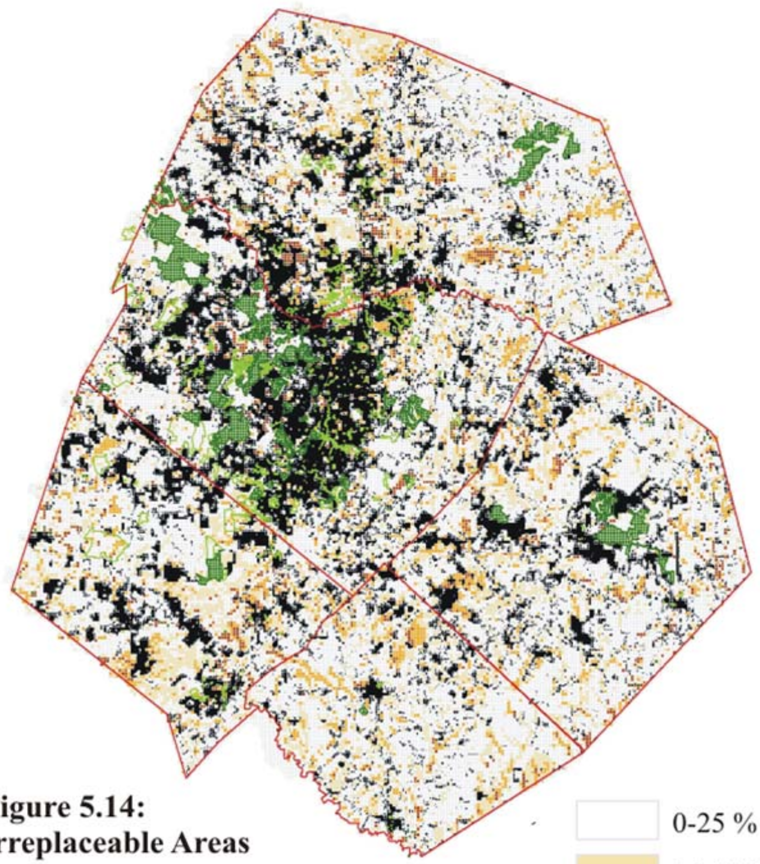


Figure 5.14: Irreplaceable Areas

Irreplaceability highlights areas prioritized in multiple conservation scenarios. The measure defines the percentage of scenarios that include that particular area in their solution sets. Areas with high irreplaceability values should be considered for immediate inclusion in conservation lands.

Evaluation of Irreplaceability through Environmental Space Graphs

Areas with irreplaceability values greater than 75% are shown in environmental space with comparisons of precipitation vs. elevation and precipitation vs. temperature (Figure 5.15). Figure 5.15a shows the following combinations of precipitation and elevation as areas with high irreplaceability values:

- 943 - 952 mm precipitation and 89 - 128 m elevation—along the Colorado River below the City of Bastrop,
- 870 - 879 mm precipitation and 152 - 162 m elevation—the headwaters of Big Sandy Creek at the north border of Bastrop County,
- 870 - 974 mm precipitation and 127 - 135 m elevation—two disparate areas: Big Sandy Creek bottom 4 km upstream from the Colorado River, and the floodplain in Brushy Creek on the eastern border of Williamson County,
- 853 - 844 mm precipitation and 149 - 156 m elevation—two areas in the Wilbarger Creek Watershed: Dry Creek 9.8 - 10.8 km upstream from its intersection with Wilbarger and Willow Creek 7.1 to 9.1 km upstream from Wilbarger,
- 853 - 859 mm precipitation and 193 - 198 m elevation— three disparate areas including: one of the largest clusters of irreplaceable cells 5.5 to 9 km Southwest of Taylor in eastern Williamson County, the headwaters of Clear Fork Plum Creek on the border of Hays and Caldwell County, and a stretch of the Blanco River 1 to 9 km upstream from the intersection with I-35 in the transition and recharge zones of the Edwards Aquifer, and
- 858 - 871 mm precipitation and 417 - 434 m elevation—the headwaters of South Onion and Onion Creeks at the western edge of Hays County.

Irreplaceability values are looked at again in environmental space by comparing average annual temperature and elevation (Figure 5.15b). This comparison again shows a number of sites dispersed throughout the study area:

- 876 - 880 mm precipitation and 19.6 - 19.8ºC temperature—an area around Wimberley in southern Hays County over the recharge zone, Big

Sandy Creek, as seen above, and tributaries of Middle Yegua Creek on the southeastern border of Williamson County,

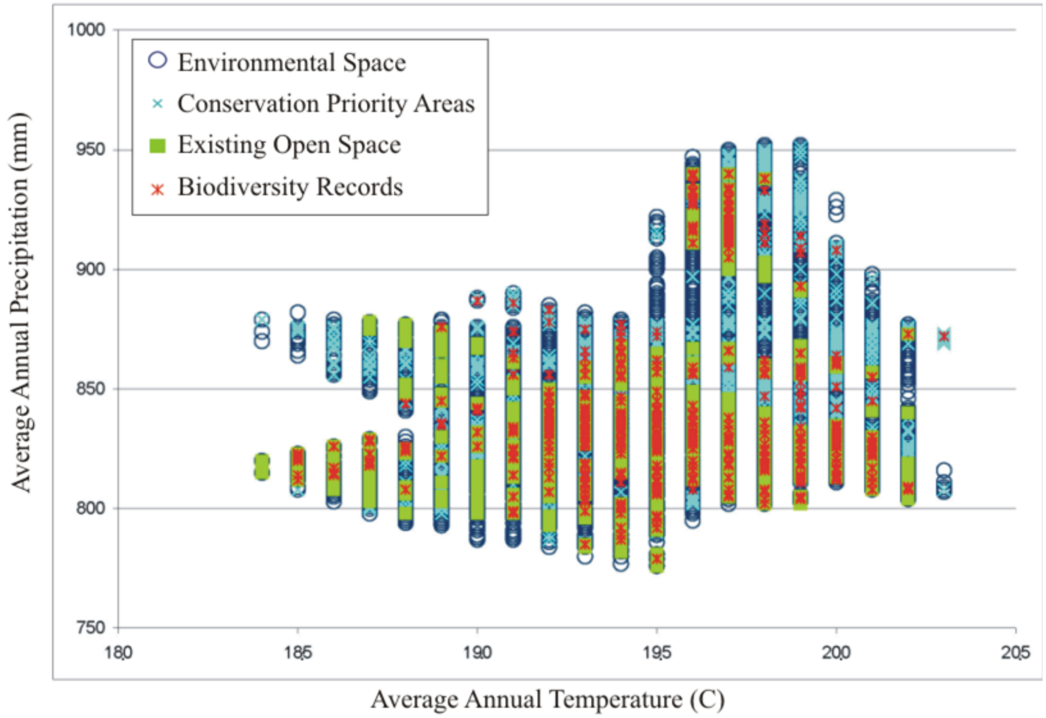
  - 861 - 875 mm precipitation and 20.0 - 20.1 ºC temperature—Big Sandy Creek 1 km upstream from Colorado River, as well as Lytton and Cedar Creek Drainages in Southeastern Bastrop County, and
  - 907 - 951 mm precipitation and 19.8 - 19.9 ºC temperature—over 4 km² in the floodplain of the Colorado River below the City of Bastrop and the drainages of Pin Oak Creek, Rocky Creek, Little Copperas Creek, and Peach Creek at the Eastern Border of Bastrop County.
- These results affirm the need for inclusion of sites throughout the study area and the ability of environmental space to show the relationship of potential conservation lands with select conservation elements.

General Description of Irreplaceable Areas in Geographic Space

Irreplaceable sites were further reviewed in geographic space to gain a greater understanding of the distribution of irreplaceable sites (Figure 5.14). These sites show a distribution of high conservation values throughout the study area. Summarized here is a sample of areas by county with the entire list of areas in the Appendix:

- **In Hays County**: headwaters of Onion Creek, areas surrounding Wimberley, segments of the Blanco River, the Edwards Aquifer recharge and transition zone, and segments of Plum Creek. Areas of note include slopes above Aquarena Springs and portions of western Hays County containing biodiversity records.
- **In Caldwell County:** sites along Plum Creek and a 2 km² area along Walnut Creek. Of special interest is a cluster of cells northwest of Lockhart.
- **In Bastrop County**: uplands in the southeastern quadrant of the county, Colorado River around Bastrop and Smithville, Pin Oak and Gravely Creek near the eastern boundary of the county, and portions of Big Sandy Creek mentioned above.

A) Average Annual Precipitation vs. Average Annual Temperature



B) Average Annual Precipitation vs. Elevation

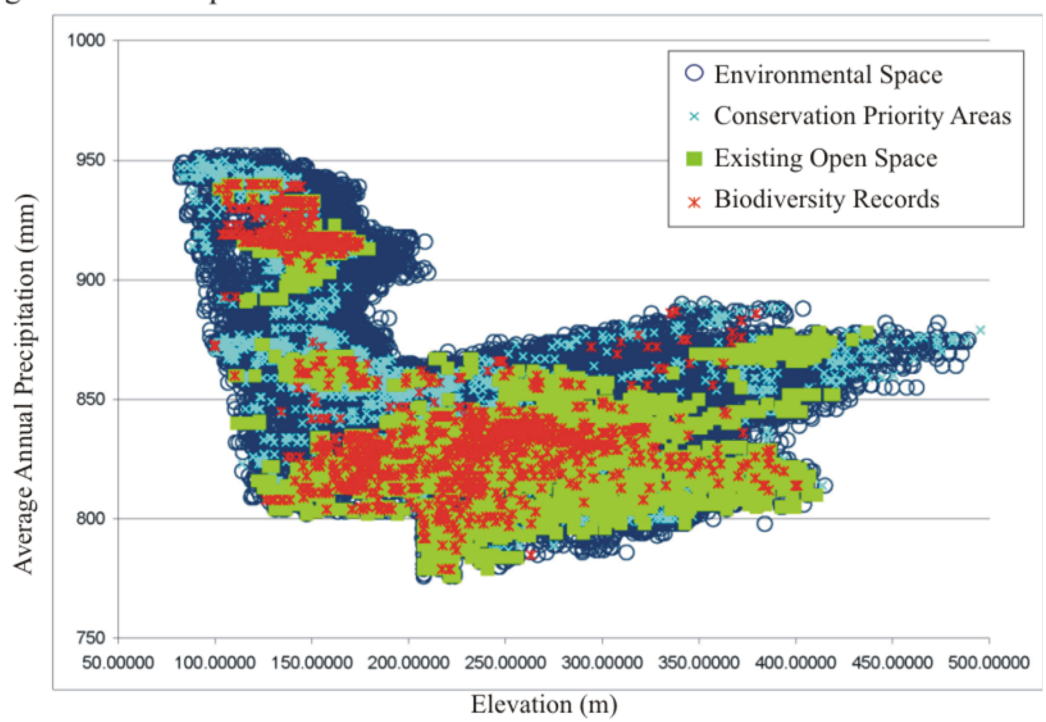


Figure 5.15 Environmental Space Graph of the Irreplaceability Set (75% or greater)

- **In Travis County:** sites associated with biodiversity records and the recharge zone, the confluence of Onion Creek and the Colorado River, Wilbarger Creek Watershed, and Colorado River Floodplain.
- **In Williamson County**: headwaters of Brushy Creek and the San Gabriel River, recharge zone and contributing zone of the Edwards Aquifer, and the largest contiguous area of high irreplaceability southwest of Taylor that is 9 km^2.

The irreplaceability sites identified and displayed in both geographic and environmental space have high conservation values. They show that the systematic conservation planning process was able to determine conservation priorities for multiple conservation elements and through the irreplaceability measure determine which areas are critical for multiple scenarios. These areas should be considered for near future inclusion in conservation lands.

CHAPTER 6: DISCUSSION AND CONCLUSIONS:

This study creates a framework for conservation planning in Central Texas and identifies areas of high conservation value. It showcases the power of environmental space graphs to understand the relationship of environmental variables to biodiversity data, existing open space, and potential open space. Using systematic conservation planning methods, forty alternative prioritization scenarios showed an array of conservation priorities, each based on a different set of conservation element targets. These scenarios were evaluated for their size, representation of conservation elements, use of lexical order, feasibility, and irreplaceability. The study also showed some of the weaknesses of the systematic conservation planning process and associated data requirements. The results of this study should be evaluated by planning professionals for inclusion in ongoing and future conservation planning processes in the study area.

DATA

A number of data issues affected this study including: scale, lack of comprehensive datasets, and lack of data standardization. Data limitations are an ongoing problem for any conservation plan as data are rarely adequate to the task of prioritizing areas and decisions are time and resource limited (Margules et al. 1994; Ferrier 2002).

A number of available biodiversity records could not be used due to scale problems. For instance, data held by the University of Texas at Austin Herbarium are primarily at the county level and are often without accurate point locations. These data could be used in studies at a state or federal scale but were not appropriate for the scale of this study. At the other end of the spectrum, a number of large parcels in western Travis County have plant survey data. Unfortunately the process for acquiring these data varied from parcel to parcel and the surveys are limited to a small section of the study area. Thus the data could not be standardized over the study area thereby making it unusable for this study.

Environmental data came from numerous sources in a number of formats and projections. The error created by converting these elements from one format to another or one projection to another is unknown. This is a problem for conservation planning and, on a larger scale, a problem for spatial data in general. While the data were evaluated for consistency and reasonableness the use of a number of data sources allows for multiple misalignments. Unfortunately, the rapid advances of geographic information systems have not allowed precautionary concerns such as data compatibility or error to keep up with use. While all these issues are surmountable, each of them adds a bit of error to the final solution (Whittaker et al. 2005; Ferrier 2002).

A number of datasets currently available for the area should be evaluated for incorporation into conservation planning. Layers such as land use, land cover, vegetation indices, refined population data, and modeled data have the potential for adding refinements to the prioritization process. The key to justifying the use of many of these data must be correlating their values with conservation concerns. For instance, if vegetation indices, such as NDVI, can be correlated with healthy stream networks, or habitat for a species of concern, this readily available data sources can be standardized over a study area at multiple scales.

A comprehensive database for the study areas that includes data important for conservation planning must be a high priority (Margules et al. 1994). The database would include information on biodiversity and abiotic variables similar to what was used in this study with the addition of greater time and focus obtaining access to all data that can be made available. Common format and projection would be used to reduce potential errors. Such an information clearinghouse would result in better decisions regarding: land use, open space acquisition, infrastructure placement, land management expenditures, and future data acquisition.

ENVIRONMENTAL SPACE GRAPHS

Environmental space graphs proved to be an effective visualization tool for demonstrating relationships between existing open space, prioritized areas, biodiversity records, and environmental variables. The graphs show lack of representation for biodiversity records and environmental variables within existing open space and the ability of prioritized areas to increase that representation. An extreme example of the visualization capabilities of environmental space graphs is the lack of data in the bottom, left corner of Figure 5.2. This lack of environmental data is the result of Lake Travis that, upon its creation, destroyed habitats within the study area. This visual clearly shows that reservoirs significantly alter and destroy habitat and the ability of environmental space graphs to illustrate environmental change.

Gaps of representation in existing open space demonstrate that much of the Blackland Prairies and parts of the Post Oak Savannah, as well as the south and west portions of Hays County are in need of conservation (Figures 5.2 and 5.3). For instance, Storm Ranch is an isolated component of conservation land with multiple conservation elements that are unrepresented in open space in its vicinity. The environmental space graphs show that the habitat surrounding Storm Ranch have characteristics not currently found in open space and therefore makes them a priority for future conservation lands.

The use of environmental space graphs to evaluate solution sets showed increased representation levels of environmental variables and biodiversity records. There are substantial increases in coverage from 5%-12% target levels, with 20% target levels having almost complete coverage of environmental space. This analysis suggested that there may be a point at which the acquisition of additional open space does not increase the representation of environmental variables in open space but will continue to increase the quantity of those variables conserved.

Further use of environmental space graphs should include the use of other variables such as geology, soil, slope, or variables not included in this study. In addition, the graphs provide an opportunity for more complex analysis through statistical and spatial analysis such as the combining of variables through ordination. This additional complexity will offer new insights into the relationships of environmental variables, biodiversity records, and open space. It should be remembered that one of the most powerful components of environmental space graphs in this study is their simplicity. Simplicity is what makes them an informative and flexible tool that can be easily incorporated into other conservation planning processes. In all cases, environmental space graphs are a powerful visualization technique to analyze the representation of biodiversity records within existing and potential conservation lands.

EVALUATION UNITS

This study, for the most part, is limited to evaluation unit of 0.25 km^2 for practical reasons associated with computational flexibility and data format. A number of studies suggest that the type and size of evaluation units influences the outcome of conservation plans (Whittaker et al. 2005). This should be investigated in greater detail for the Austin area. In particular, watersheds deserve further study as evaluation units for conservation planning. This study included watersheds as an evaluation unit for preliminary analysis and found them to be substantially less efficient with respect to total area of solution sets than square grid cells when using only biodiversity records. If, however, new data or new insights into land management show watersheds to be a feasible evaluation unit for conservation planning it would allow for greater integration of datasets from the two primary motivators of conservation in the study area—biodiversity and water quality. This potential alignment of multiple land management issues allows for better decision-making and a more efficient use of resources (Karr 2000).

PRIORITIZATION PROCESS

Using systematic conservation planning tools, forty prioritization runs demonstrated the effects of different conservation elements in determining priority areas. Prioritizations resulted in additions of conservation lands ranging from 21.25 to 2,323.25 km^2— 0.19 to 20.44% of the study area. The extremes of this range guide the placement of realistic conservation plans within the context of potential options. This is not to say that 20% of the study area is an unreasonable open space goal, but it is not a near reality due to resource constraints and the lack of public acceptance.

Runs solely for biodiversity records lead to minimal increases in conservation land area. There are few recorded sites of biodiversity in the study area making these sites high priorities for immediate incorporation into conservation lands. Introducing environmental, water, and vulnerability variables resulted in large variations in the patterns of solution sets as evidenced by comparisons of areas in common and the hamming distance. This clearly shows that there is not one right answer to conservation.

Establishment of goals and targets must be stated clearly for all conservation planning processes, as the results are contingent on initial presumptions.

Lexical Order

An interesting pattern occurred between solution sets that used only environmental variables of weather, topography, and substrate as compared with those that used additional variables for water, watersheds, and vulnerability. The total size of solution sets decreased with the addition of conservation elements to the target sets. There is no rational in the conservation planning literature to explain a decrease in the size of solution sets with an increase in the number of conservation elements. The selection of areas by lexical order was evaluated as the potential reason for this anomaly.

The algorithms embedded in the ResNet program use complementarity to select conservation priority areas. If two or more areas have the same complementarity value—they are tied—the area with the lowest index number is chosen, known as lexical order. Selection by lexical order is not necessarily an issue because areas have already been evaluated by complementarity and therefore have conservation value. The use of lexical order should not, however, make a solution set bigger, as appears to be the case in this study. It appears that the addition of conservation elements at low target levels reduced complementarity value ties. This resulted in reduced selection by lexical order and smaller overall solution sets. This issue needs to be looked at in further detail.

Non-Traditional Conservation Elements

While the use of both vulnerability and water variables are unconventional, they make sense from an implementation perspective. Vulnerability variables preferred areas for conservation adjacent to transformed areas—the city limits. These are the areas at most risk of transformation and are currently under the jurisdiction of a municipalities that have a stake in future land use through their extra territorial jurisdictions.

Critical water quality areas and Edwards Aquifer variables are essential to a number of conservation efforts within the study area. In addition, the large budgets associated with water quality and the ecological significance of watersheds justifies the alignment of priority areas with watersheds. As these elements are important for biodiversity and water resources and they have high public acceptance, they will be a part of any comprehensive conservation plan for the area. Finally, with the right balance of target levels, neither the vulnerability nor the water variables increased the size of the solution sets. This suggests that the efficiencies built into the complementarity decision process are able to incorporate these variables and refine the selection of areas for conservation without adding to the size of the solution set.

Further Evaluation of Solution Sets

As good surveys should be based on environmental stratification, it follows that conservation plans should be based on environmental stratification to ensure that all conservation elements, known and unknown, are represented in conservation lands and that ecological services can be maintained to support human communities. Three Solution sets, TS-11, TS-25, and TS-40 were looked at in greater detail for implementation. If implemented each of these solution sets would protect water quality and prioritize the most vulnerable sites, while conserving lands associated with biodiversity records and the environmental variables used as conservation elements. These solution sets resulted in additional conservation lands of 5 to 20% of the study area. They should be evaluated in greater detail by planning professionals for potential implementation.

IRREPLACEABILITY

Irreplaceability measures the ability of a particular area to be replaced by another to reach stated conservation goals. The irreplaceability value of a particular evaluation unit was determined by its reoccurrence in multiple solution sets. This suggests that regardless of which conservation elements are used or in what percentages, these sites are important for conservation. The irreplaceability measurement is a useful component of this study that provided immediate, viable options for conservation planning and helped to overcome some of the problems associated with spatial data and the systematic conservation planning process.

By using multiple outcomes to determine the irreplaceability value, any error associated with one dataset is reduced in importance. As there are issues with unknown error associated with spatial data, this is an important strength of the irreplaceability measure as used in this study. This lack of dependence on any one dataset reduces the potential for erroneous prioritizations—it reduces the chance of a false positive.

Each of the areas with an irreplaceability score greater than or equal to 75% are listed in the Appendix. These sites should be looked at immediately for inclusion in conservation areas. Two examples are a large area (9 km^2) in eastern Williamson County and one in southern Hays County (Figure 5.14). A large cluster of evaluation units southwest of Taylor in Williamson County have high irreplaceability values. It is surprising that a large contiguous area in the Blackland Prairie would have such high irreplaceability values because, while the prairies as a whole are in great danger of disappearing, many of the environmental variables associated with them are common within the study area, even if they are unrepresented in open space. A number of evaluation units have high irreplaceability values just upstream from Aquarena Springs in San Marcos in southern Hays County. These are important sites as they are very close to development, are currently not in public hands, and are upstream from a number of endangered species and conservation elements. Both of these areas as well as others with high irreplaceability merit inclusion in conservation lands. Sites above Aquarena Springs have the potential for incorporation into the Hays County Regional Habitat Conservation Plan. For the sites near Taylor another mechanism must be found as there are few incentives for conserving the much endangered prairies.

PROBLEMS WITH THE SYSTEMATIC CONSERVATION PLANNING APPROACH

Systematic conservation planning ideally delivers the most efficient conservation plan—defined as the one that takes up the least amount of space—while meeting quantifiable goals. It has been shown to be the most efficient conservation planning procedure currently in use with respect to area needed to meet conservation goals (Pressey 1993; Margules and Pressey 2000). There are, however, a number of problems with these techniques that influenced the results of this study: the process is computationally intensive, results are not dynamic, the assertion of a quantitative process belies subjectivity, and the tools are not accessible to many planning professionals.

The computational complexity stems from the immense amount of data to undertake the process and, in the case of this study, the uniqueness of the formats and procedures associated with the ResNet software program. Data sets for ResNet must be converted from spatial data to spreadsheets then to cross-tab text files that are then used in the program. The results from ResNet come as text files that are turned into database files to be imported into a spatial analysis program to evaluate and explain results. This process can and should be imbedded in a geographic information system (GIS) environment to reduce the amount of data manipulations that provide multiple opportunities for error. In addition, a more accessible format would lead to more users who currently do not have access to systematic conservation planning tools due to time, resource, and skill constraints. This access would naturally lead to more practical applications of systematic conservation planning and could lead to innovative approaches.

Much of the systematic conservation planning literature speaks to the quantitative nature of the process (Margules, Pressey, and Williams 2002; Pressey et al. 2000). This is an understandable reaction to a number of documented inefficient, unquantifiable conservation planning processes (Pressey et al. 1993). The process, however, of creating a comprehensive conservation plan takes a number of years, substantial financial resources, and is imbedded in socio-economic issues. To make systematic conservation planning processes more widely used, it must acknowledge and integrate these portions of the planning process. This could happen through greater incorporation of stakeholder and expert opinion, field work, more focus on land-use variables such as land ownership and vulnerability, the incorporation of water resource variables, hierarchical strategies for acquisition, more accessible analysis formats, or other innovations that make implementation of conservation plans a closer reality. This study makes strides towards creating more practical results through the incorporation of water resource and vulnerability data in the prioritization process.

Within this study there are forty solution sets, each based on different criteria. It is clear that there is no likelihood for any particular solution set to be implemented entirely or within a short time frame. This reality of time and resources is not acknowledged by the static solution sets found through this study and the exact answers found will quickly become outdated as the realities of long-term land acquisition programs and land transformation change the available options for conservation. While the conservation planning processes should be embedded in the most stringent scientific methodologies possible, it should also have the flexibility to accommodate other societal perspectives, decision making tools, and goals (Pressey and Cowling 2001; Whittaker et al. 2005).

NEXT STEPS

The results of this study can and should be elaborated on through further analysis, stakeholder input, and field testing in the interest of moving towards the implementation of a comprehensive conservation plan. The pieces of information found through this study are ready for input from experts and stakeholders responsible for conservation planning decisions in the area. The solution sets, and in particular, the irreplaceability sites should be evaluated for immediate incorporation into conservation lands.

Further analysis should happen both within the ResNet program as well as other available systematic conservation planning programs. Other systematic conservation planning programs, such as Marxan and C-Plan, should be used to compare conservation priority outcomes, as well as the benefits of particular programs (Margules, Pressey, and Williams 2002). Using the same procedures used in this study, prioritizations should be run with presence / absence data rather than probability data, using the adjacency selection tool in ResNet, and further evaluating lexical order selection.

In this study probabilistic data was used following Sahotra et al. (2004). This process created another layer of complexity that’s benefit is unclear. By running the prioritizations with presences / absence data the results can justify the additional computational complexity. The adjacency tool can be used in ResNet to select sites that are bordered by areas already included in the solution set if more than one area has the same complementarity values. This step would come before the use of lexical order to select sites. Finally, lexical order should be investigated further to understand if it is the cause of some solution sets with fewer conservation elements having increased size. In all cases the results of further analysis should be compared to the results found here to validate areas as conservation priorities or to show contradictory results.

POTENTIAL FOR THE FUTURE

As the human population continues to grow in the coming decades a number of choices will need to be made regarding conservation of biodiversity and ecological functionality in Central Texas. The incessant pressure to develop car dependent communities with commercial strips along every thoroughfare is one potential for the area. This would result in a loss of species, unique habitats, and aesthetics. Under current accounting practices the costs of such disregard for functioning natural systems would be hidden in the long-term tax burden as increased infrastructure costs, increased water management costs, and increased health issues related to the environment.

This study shows a path forward for a comprehensive conservation plan in Central Texas. Successful implementation will result in a framework for regional plans. It will sustain and conserve the existing natural systems that support societal needs and add additional economic prosperity through higher land values and more viable communities.

The areas identified with high irreplaceable values deserve immediate evaluation for inclusion in conservation lands. In addition, environmental space graphs and the conservation priority areas repeatedly demonstrate the need for additional conservation areas in the eastern two thirds of the study area, as well as southern and western Hays County. A number of the resulting solution sets have implementation potential and should be further investigated by planning professionals. These steps should be taken in a time frame that acknowledges the speed at which human population growth is transforming the study area.

The Envision Central Texas project articulated an alternative future that includes the expansion of current urban areas to accommodate the increasing population with more dense development, more walkable communities, less infrastructure, and greater amounts of open space. This study acknowledges that plan and suggests a way forward to best utilize conservation resources. This type of comprehensive planning allows for the long-term health of natural systems and human communities in the study area.

APPENDIX: CENTROID COORDINATES FOR EVALUATION UNITS WITH IRREPLACEABILITY VALUES GREATER THAN 75%

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
100%	568250	3323250	30.0383868320	-98.2920989351	HAYS
100%	571250	3322750	30.0337038086	-98.2610180038	HAYS
100%	571750	3332750	30.1239119581	-98.2551567769	HAYS
100%	571750	3333250	30.1284237941	-98.2551229088	HAYS
100%	573250	3333750	30.1328463569	-98.2395171181	HAYS
100%	574250	3332750	30.1237622028	-98.2292059842	HAYS
100%	579250	3355250	30.3264730415	-98.1756132634	HAYS
100%	579750	3342250	30.2091373351	-98.1713982699	HAYS
100%	580250	3342250	30.2091044002	-98.1662037343	HAYS
100%	585750	3377250	30.5245337926	-98.1061966914	TRAVIS
100%	587250	3365250	30.4161517365	-98.0915689126	TRAVIS
100%	588750	3328750	30.0866993328	-98.0790302859	HAYS
100%	589250	3326250	30.0641045617	-98.0740523914	HAYS
100%	589250	3371750	30.4746534434	-98.0701910524	TRAVIS
100%	591750	3384750	30.5917591561	-98.0429997738	TRAVIS
100%	592750	3317750	29.9871457950	-98.0384854199	HAYS
100%	592750	3395250	30.6864176167	-98.0316271820	WILLIAMSON
100%	593750	3301750	29.8426948771	-98.0295210134	HAYS
100%	593750	3317250	29.9825580320	-98.0281638639	HAYS
100%	594250	3301250	29.8381449856	-98.0243896026	HAYS
100%	594250	3371750	30.4742717148	-98.0181071747	TRAVIS
100%	594750	3371750	30.4742323983	-98.0128988423	TRAVIS
100%	595250	3301750	29.8425798685	-98.0139952528	HAYS
100%	596250	3387750	30.6184726924	-97.9957891459	WILLIAMSON
100%	599250	3404750	30.7716041627	-97.9628544401	WILLIAMSON
100%	599250	3405250	30.7761151913	-97.9628060476	WILLIAMSON
100%	599750	3403750	30.7625402240	-97.9577274925	WILLIAMSON
100%	600250	3311250	29.9279045001	-97.9613551508	HAYS
100%	601250	3309750	29.9142876754	-97.9511379490	HAYS
100%	601750	3373750	30.4917049251	-97.9397877191	TRAVIS
100%	602750	3309750	29.9141631829	-97.9356014745	HAYS
100%	603250	3316250	29.9727714880	-97.9297949104	HAYS
100%	603750	3386750	30.6088229053	-97.9176506470	WILLIAMSON
100%	604750	3387250	30.6132467565	-97.9071692946	WILLIAMSON
100%	605250	3387250	30.6132028308	-97.9019537236	WILLIAMSON
100%	606250	3403750	30.7619767513	-97.8898204113	WILLIAMSON
100%	606750	3355750	30.3288687494	-97.8895368431	TRAVIS
100%	606750	3386750	30.6085587706	-97.8863587058	WILLIAMSON
100%	606750	3387250	30.6130697991	-97.8863070798	WILLIAMSON
100%	607250	3386750	30.6085140166	-97.8811434227	WILLIAMSON
100%	607750	3402250	30.7483089437	-97.8743072830	WILLIAMSON
100%	608750	3402250	30.7482178882	-97.8638617431	WILLIAMSON

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
100%	609750	3329250	30.0895030587	-97.8610915644	HAYS
100%	609750	3374250	30.4955115703	-97.8563901914	TRAVIS
100%	610250	3329750	30.0939693309	-97.8558518308	HAYS
100%	610250	3334750	30.1390825507	-97.8553316997	TRAVIS
100%	610750	3329750	30.0939240508	-97.8506638219	HAYS
100%	610750	3330750	30.1029467039	-97.8505594189	HAYS
100%	610750	3334750	30.1390371887	-97.8501413335	TRAVIS
100%	610750	3335250	30.1435484850	-97.8500890196	TRAVIS
100%	610750	3373750	30.4909087100	-97.8460250711	WILLIAMSON
100%	611250	3331250	30.1074125160	-97.8453184960	HAYS
100%	611250	3401250	30.7389648514	-97.8378564235	WILLIAMSON
100%	611750	3401250	30.7389179743	-97.8326342184	WILLIAMSON
100%	612250	3346750	30.2471695078	-97.8332944573	TRAVIS
100%	612250	3359750	30.3644595366	-97.8319044424	TRAVIS
100%	613250	3377750	30.5267635282	-97.8195446526	WILLIAMSON
100%	614250	3371750	30.4725368827	-97.8097824379	WILLIAMSON
100%	614750	3372750	30.4815112319	-97.8044643123	WILLIAMSON
100%	616250	3379250	30.5400092675	-97.7881121141	WILLIAMSON
100%	618250	3388250	30.6210090471	-97.7662386661	WILLIAMSON
100%	620750	3399250	30.7199954463	-97.7388716445	WILLIAMSON
100%	621750	3392750	30.6612542907	-97.7291981592	WILLIAMSON
100%	622250	3373750	30.4897932393	-97.7262229580	WILLIAMSON
100%	622750	3368250	30.4401228142	-97.7216625549	TRAVIS
100%	623250	3337250	30.1603918422	-97.7200949705	TRAVIS
100%	623250	3368250	30.4400717123	-97.7164565734	TRAVIS
100%	624750	3372250	30.4760037632	-97.7003597574	WILLIAMSON
100%	624750	3386750	30.6068159617	-97.6986162820	WILLIAMSON
100%	625250	3386750	30.6067636844	-97.6934014548	WILLIAMSON
100%	626250	3359750	30.3630765036	-97.6862480602	TRAVIS
100%	626750	3382250	30.5660093390	-97.6783080428	WILLIAMSON
100%	627750	3399750	30.7237752769	-97.6657168860	WILLIAMSON
100%	628750	3388250	30.6199238065	-97.6567112399	WILLIAMSON
100%	628750	3402750	30.7507307982	-97.6548988689	WILLIAMSON
100%	628750	3403250	30.7552413353	-97.6548361617	WILLIAMSON
100%	629250	3382750	30.5702527752	-97.6521828078	WILLIAMSON
100%	629250	3401750	30.7416554756	-97.6498022549	WILLIAMSON
100%	629750	3387750	30.6153050266	-97.6463431394	WILLIAMSON
100%	629750	3388750	30.6243262540	-97.6462175902	WILLIAMSON
100%	630250	3388250	30.6197612461	-97.6410649591	WILLIAMSON
100%	630250	3388750	30.6242718485	-97.6410019357	WILLIAMSON
100%	633250	3281750	29.6586110998	-97.6231784277	CALDWELL
100%	633750	3278750	29.6314899618	-97.6183830692	CALDWELL
100%	634250	3282750	29.6675258085	-97.6127245126	CALDWELL
100%	634250	3342250	30.2043365264	-97.6052558483	TRAVIS
100%	634750	3282750	29.6674716332	-97.6075590189	CALDWELL
100%	640750	3350250	30.2757714988	-97.5366753784	TRAVIS
100%	640750	3350750	30.2802821359	-97.5366084398	TRAVIS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
100%	641250	3348750	30.2621814036	-97.5316799337	TRAVIS
100%	641250	3351250	30.2847345530	-97.5313441291	TRAVIS
100%	666750	3323250	30.0289247500	-97.2707137320	BASTROP
100%	666750	3323750	30.0334349711	-97.2706354103	BASTROP
100%	667250	3323250	30.0288565043	-97.2655304495	BASTROP
100%	670750	3307250	29.8840474524	-97.2318047086	BASTROP
100%	671750	3307250	29.8839083009	-97.2214533981	BASTROP
100%	672750	3351250	30.2806512105	-97.2039435342	BASTROP
100%	673250	3351250	30.2805797991	-97.1987472588	BASTROP
100%	673750	3351250	30.2805081815	-97.1935510020	BASTROP
100%	674250	3351750	30.2849462050	-97.1882718809	BASTROP
100%	674750	3311250	29.9195668836	-97.1897475528	BASTROP
100%	680750	3315250	29.9547785124	-97.1269442823	BASTROP
100%	681750	3317250	29.9726703524	-97.1162459630	BASTROP
100%	682750	3348250	30.2521260272	-97.1005427265	BASTROP
100%	682750	3348750	30.2566356690	-97.1004559260	BASTROP
97%	569250	3326250	30.0654020929	-98.2815320370	HAYS
97%	572750	3336750	30.1599471862	-98.2445014983	HAYS
97%	573250	3337250	30.1644289867	-98.2392748120	HAYS
97%	574250	3339750	30.1869272433	-98.2287145910	HAYS
97%	574750	3339250	30.1823848370	-98.2235565360	HAYS
97%	574750	3339750	30.1868965996	-98.2235211481	HAYS
97%	575250	3339750	30.1868657504	-98.2183277132	HAYS
97%	577750	3333750	30.1325674678	-98.1928018024	HAYS
97%	578750	3333750	30.1325032357	-98.1824207113	HAYS
97%	585250	3365250	30.4162949440	-98.1123904242	TRAVIS
97%	586250	3364750	30.4117122911	-98.1020209537	TRAVIS
97%	593250	3317750	29.9871078476	-98.0333026678	HAYS
97%	598750	3402250	30.7490906110	-97.9683192196	WILLIAMSON
97%	598750	3404750	30.7716458392	-97.9680786380	WILLIAMSON
97%	599750	3404250	30.7670512515	-97.9576788783	WILLIAMSON
97%	600250	3403750	30.7624981417	-97.9525038035	WILLIAMSON
97%	603250	3334250	30.1351846597	-97.9280468030	HAYS
97%	603250	3362250	30.3878191892	-97.9252990282	TRAVIS
97%	603250	3407750	30.7983289359	-97.9207590336	WILLIAMSON
97%	603750	3315750	29.9682177533	-97.9246616692	HAYS
97%	604250	3314750	29.9591523004	-97.9195776970	HAYS
97%	604250	3319250	29.9997559258	-97.9191380893	HAYS
97%	607250	3320250	30.0085198014	-97.8879383516	HAYS
97%	607250	3409250	30.8115067539	-97.8787977536	WILLIAMSON
97%	608250	3398250	30.7121761681	-97.8695058265	WILLIAMSON
97%	608750	3325750	30.0580129435	-97.8718255391	HAYS
97%	608750	3353250	30.3061344492	-97.8689944122	TRAVIS
97%	609250	3326250	30.0624797202	-97.8665879812	HAYS
97%	610250	3373750	30.4909547125	-97.8512340078	WILLIAMSON
97%	610250	3389250	30.6307959296	-97.8495852646	WILLIAMSON
97%	612750	3380750	30.5538765174	-97.8244294414	WILLIAMSON

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
97%	613750	3348750	30.2650744016	-97.8174903368	TRAVIS
97%	613750	3381250	30.5582929391	-97.8139501062	WILLIAMSON
97%	614250	3381250	30.5582453528	-97.8087376462	WILLIAMSON
97%	615250	3378750	30.5355948921	-97.7985905522	WILLIAMSON
97%	615250	3400750	30.7340731555	-97.7961352167	WILLIAMSON
97%	615750	3378750	30.5355467232	-97.7933793339	WILLIAMSON
97%	615750	3379250	30.5400576535	-97.7933235605	WILLIAMSON
97%	620250	3356250	30.3321121962	-97.7490727306	TRAVIS
97%	621250	3368750	30.4447857751	-97.7372224343	TRAVIS
97%	621750	3317750	29.9846077934	-97.7379038304	CALDWELL
97%	621750	3318250	29.9891190089	-97.7378467662	CALDWELL
97%	622250	3367250	30.4311519337	-97.7269857577	TRAVIS
97%	624250	3355750	30.3271966924	-97.7075298328	TRAVIS
97%	624750	3335750	30.1467058771	-97.7046982320	TRAVIS
97%	625750	3382250	30.5661147685	-97.6887332856	WILLIAMSON
97%	628750	3383250	30.5748173140	-97.6573334500	WILLIAMSON
97%	629250	3382250	30.5657421145	-97.6522451786	WILLIAMSON
97%	629250	3383250	30.5747634327	-97.6521204230	WILLIAMSON
97%	630250	3339250	30.1777065039	-97.6471726735	TRAVIS
97%	631750	3411250	30.8270797912	-97.6224714393	WILLIAMSON
97%	632250	3413750	30.8495761375	-97.6169214761	WILLIAMSON
97%	632750	3340750	30.1909687873	-97.6210244210	TRAVIS
97%	632750	3341250	30.1954796482	-97.6209615541	TRAVIS
97%	633250	3414750	30.8584847823	-97.6063355640	WILLIAMSON
97%	634750	3282250	29.6629604365	-97.6076211598	CALDWELL
97%	640750	3349250	30.2667502149	-97.5368092102	TRAVIS
97%	640750	3349750	30.2712608585	-97.5367423019	TRAVIS
97%	641250	3348250	30.2576707640	-97.5317470491	TRAVIS
97%	641750	3284250	29.6802251971	-97.5350474309	CALDWELL
97%	642750	3347750	30.2529844547	-97.5162271552	TRAVIS
97%	642750	3348250	30.2574950660	-97.5161593434	TRAVIS
97%	642750	3348750	30.2620056740	-97.5160915161	TRAVIS
97%	643250	3348250	30.2574360879	-97.5109634721	TRAVIS
97%	643750	3343750	30.2167814773	-97.5063816374	TRAVIS
97%	651750	3361750	30.3781819009	-97.4206836764	TRAVIS
97%	658250	3345250	30.2285093236	-97.3555454723	BASTROP
97%	658750	3342750	30.2058926336	-97.3507278536	BASTROP
97%	658750	3343250	30.2104029196	-97.3506526221	BASTROP
97%	665250	3360250	30.3628784763	-97.2804721801	BASTROP
97%	665750	3360250	30.3628099350	-97.2752713487	BASTROP
97%	666750	3304250	29.8575339198	-97.2736768298	BASTROP
97%	667250	3302750	29.8439351228	-97.2687359573	BASTROP
97%	667750	3302250	29.8393568456	-97.2636403035	BASTROP
97%	667750	3322250	30.0197676520	-97.2605047125	BASTROP
97%	668250	3322250	30.0196990230	-97.2553219344	BASTROP
97%	668750	3321750	30.0151200087	-97.2502183799	BASTROP
97%	668750	3322250	30.0196301902	-97.2501391743	BASTROP

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
97%	669750	3305250	29.8661447535	-97.2424725189	BASTROP
97%	670750	3308750	29.8975781220	-97.2315658025	BASTROP
97%	671250	3310750	29.9155494063	-97.2260697132	BASTROP
97%	671250	3322750	30.0237930816	-97.2241452486	BASTROP
97%	672250	3323750	30.0326729091	-97.2136177120	BASTROP
97%	672750	3307750	29.8882785139	-97.2110216120	BASTROP
97%	672750	3323750	30.0326024063	-97.2084343939	BASTROP
97%	672750	3324250	30.0371124737	-97.2083532404	BASTROP
97%	682750	3330750	30.0942864668	-97.1035683979	BASTROP
97%	683750	3343750	30.2113882375	-97.0909383903	BASTROP
97%	687750	3329750	30.0845082439	-97.0518840855	BASTROP
97%	689250	3326750	30.0572190620	-97.0368618944	BASTROP
97%	689250	3327250	30.0617286681	-97.0367728839	BASTROP
94%	571250	3322250	30.0291919015	-98.2610514762	HAYS
94%	573250	3336250	30.1554053939	-98.2393440815	HAYS
94%	581750	3314750	29.9608580748	-98.1527381354	HAYS
94%	584250	3359750	30.3667387448	-98.1232445466	TRAVIS
94%	587750	3321250	30.0190961775	-98.0900253210	HAYS
94%	588750	3359250	30.3619047654	-98.0764622519	TRAVIS
94%	591750	3317250	29.9827093864	-98.0488939549	HAYS
94%	595250	3359250	30.3614093936	-98.0088310740	TRAVIS
94%	596250	3306750	29.8876193096	-98.0031964085	HAYS
94%	599250	3401750	30.7445379238	-97.9631445661	WILLIAMSON
94%	600250	3372750	30.4828086401	-97.9555115521	TRAVIS
94%	600750	3309750	29.9143287663	-97.9563167953	HAYS
94%	601250	3398750	30.7173031204	-97.9425492955	WILLIAMSON
94%	601750	3322250	30.0270353381	-97.9447677867	HAYS
94%	601750	3398250	30.7127494506	-97.9373775376	WILLIAMSON
94%	601750	3398750	30.7172604833	-97.9373280721	WILLIAMSON
94%	602750	3306750	29.8870936298	-97.9358891869	HAYS
94%	602750	3310250	29.9186747640	-97.9355534843	HAYS
94%	604750	3362750	30.3922010468	-97.9096381944	TRAVIS
94%	606250	3337750	30.1665062252	-97.8965537400	TRAVIS
94%	606750	3321750	30.0220978467	-97.8929716574	HAYS
94%	607250	3352750	30.3017571092	-97.8846430685	TRAVIS
94%	608750	3320750	30.0128989086	-97.8723365091	HAYS
94%	608750	3349750	30.2745558839	-97.8693566988	TRAVIS
94%	609750	3333750	30.1301050727	-97.8606257263	HAYS
94%	609750	3350250	30.2789769165	-97.8589095045	TRAVIS
94%	610250	3349750	30.2744202980	-97.8537642181	TRAVIS
94%	611250	3413750	30.8517354257	-97.8364989046	WILLIAMSON
94%	611750	3346750	30.2472156844	-97.8384904667	TRAVIS
94%	611750	3347250	30.2517268877	-97.8384373930	TRAVIS
94%	612750	3414750	30.8606150421	-97.8207036362	WILLIAMSON
94%	612750	3415250	30.8651257914	-97.8206484175	WILLIAMSON
94%	615250	3383750	30.5807041363	-97.7980346611	WILLIAMSON
94%	618250	3395750	30.6886710879	-97.7653789787	WILLIAMSON

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
94%	618750	3360750	30.3728595895	-97.7641635410	TRAVIS
94%	620250	3296750	29.7952808334	-97.7558058514	CALDWELL
94%	620750	3393750	30.6703774285	-97.7395167078	WILLIAMSON
94%	621250	3391250	30.6477729675	-97.7345922788	WILLIAMSON
94%	621750	3406750	30.7875536013	-97.7275401618	WILLIAMSON
94%	623250	3394250	30.6746323712	-97.7133654451	WILLIAMSON
94%	624250	3372250	30.4760555620	-97.7055676166	WILLIAMSON
94%	625750	3380250	30.5480718267	-97.6889758822	WILLIAMSON
94%	625750	3386750	30.6067111982	-97.6881866413	WILLIAMSON
94%	626250	3379750	30.5435085197	-97.6838250734	WILLIAMSON
94%	626750	3379250	30.5389450200	-97.6786747461	WILLIAMSON
94%	627750	3391750	30.6516056208	-97.6667091667	WILLIAMSON
94%	629750	3366250	30.4213454998	-97.6490287767	TRAVIS
94%	629750	3409750	30.8137690246	-97.6435679261	WILLIAMSON
94%	631250	3362750	30.3896078011	-97.6338540760	TRAVIS
94%	631750	3392750	30.6601918440	-97.6248445519	WILLIAMSON
94%	631750	3394750	30.6782339993	-97.6245889530	WILLIAMSON
94%	632250	3340250	30.1865124174	-97.6262796657	TRAVIS
94%	632250	3340750	30.1910232913	-97.6262170496	TRAVIS
94%	632250	3392750	30.6601365232	-97.6196270192	WILLIAMSON
94%	634750	3291250	29.7441614893	-97.6065004589	CALDWELL
94%	634750	3291750	29.7486726285	-97.6064380632	CALDWELL
94%	635250	3291250	29.7441069443	-97.6013310557	CALDWELL
94%	637250	3293750	29.7664421601	-97.5803356803	CALDWELL
94%	639750	3345250	30.2307805146	-97.5477329965	TRAVIS
94%	641250	3350750	30.2802239296	-97.5314113204	TRAVIS
94%	646250	3291250	29.7428558921	-97.4876078780	CALDWELL
94%	648250	3364750	30.4056793988	-97.4566727496	TRAVIS
94%	651250	3361250	30.3737343471	-97.4259579876	TRAVIS
94%	652250	3362250	30.3826292217	-97.4154088878	TRAVIS
94%	652750	3331750	30.1074317095	-97.4146306043	BASTROP
94%	657750	3345250	30.2285744106	-97.3607394360	BASTROP
94%	659250	3344250	30.2193580070	-97.3453086518	BASTROP
94%	663250	3297750	29.7993667948	-97.3108849203	BASTROP
94%	664750	3359250	30.3539267471	-97.2858303586	BASTROP
94%	665250	3359250	30.3538584373	-97.2806299860	BASTROP
94%	665250	3359750	30.3583684584	-97.2805510920	BASTROP
94%	665250	3361250	30.3718985020	-97.2803143028	BASTROP
94%	665750	3359750	30.3582999295	-97.2753504990	BASTROP
94%	665750	3360750	30.3673199373	-97.2751921805	BASTROP
94%	666750	3302750	29.8440028636	-97.2739096721	BASTROP
94%	667750	3323250	30.0287880546	-97.2603471848	BASTROP
94%	668250	3322750	30.0242092136	-97.2552429452	BASTROP
94%	668250	3323250	30.0287194009	-97.2551639380	BASTROP
94%	668250	3368750	30.4391326595	-97.2478988619	WILLIAMSON
94%	669250	3304750	29.8617032889	-97.2477261363	BASTROP
94%	669250	3321750	30.0150509844	-97.2450358720	BASTROP

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
94%	681250	3329750	30.0854905628	-97.1192978980	BASTROP
94%	682750	3328250	30.0717376257	-97.1039986819	BASTROP
94%	684750	3326250	30.0533978480	-97.0836063027	BASTROP
94%	684750	3328250	30.0714367633	-97.0832586703	BASTROP
90%	573750	3320250	30.0109961820	-98.2352638645	HAYS
90%	573750	3321750	30.0245318513	-98.2351599956	HAYS
90%	578750	3346750	30.2498077583	-98.1814510783	HAYS
90%	586750	3309250	29.9108849504	-98.1013691481	HAYS
90%	587750	3310750	29.9243493407	-98.0908884103	HAYS
90%	593750	3371250	30.4697995012	-98.0233605433	TRAVIS
90%	598250	3344250	30.2258274570	-97.9790202576	TRAVIS
90%	602750	3371750	30.4735750563	-97.9295669598	TRAVIS
90%	605250	3322750	30.0312507125	-97.9084258518	HAYS
90%	605750	3313250	29.9454893868	-97.9041828522	HAYS
90%	605750	3313750	29.9500008997	-97.9041333832	HAYS
90%	605750	3314250	29.9545124094	-97.9040839030	HAYS
90%	605750	3314750	29.9590239159	-97.9040344115	HAYS
90%	606250	3352750	30.3018453262	-97.8950410369	TRAVIS
90%	606250	3358750	30.3559801632	-97.8944330737	TRAVIS
90%	606250	3359250	30.3604913789	-97.8943823356	TRAVIS
90%	606250	3361750	30.3830474094	-97.8941284727	TRAVIS
90%	606250	3362250	30.3875586059	-97.8940776657	TRAVIS
90%	606750	3343250	30.2160870400	-97.8908057961	TRAVIS
90%	606750	3413750	30.8521497059	-97.8835541665	WILLIAMSON
90%	607250	3352250	30.2972458679	-97.8846941334	TRAVIS
90%	607750	3307750	29.8956889468	-97.8840151240	HAYS
90%	608250	3321250	30.0174546510	-97.8774695248	HAYS
90%	608250	3409250	30.8114158924	-97.8683453665	WILLIAMSON
90%	609250	3320250	30.0083429749	-97.8672039625	HAYS
90%	609750	3334250	30.1346163917	-97.8605739079	TRAVIS
90%	610750	3383250	30.5766180526	-97.8450113474	WILLIAMSON
90%	611750	3414250	30.8561991120	-97.8312158982	WILLIAMSON
90%	613250	3311750	29.9312861388	-97.8266373428	HAYS
90%	613750	3378750	30.5357381486	-97.8142242821	WILLIAMSON
90%	615250	3380750	30.5536386284	-97.7983683464	WILLIAMSON
90%	615750	3380750	30.5535904250	-97.7931561649	WILLIAMSON
90%	619250	3381250	30.5577580183	-97.7566137396	WILLIAMSON
90%	619250	3381750	30.5622688710	-97.7565562163	WILLIAMSON
90%	619750	3379250	30.5396647301	-97.7516323465	WILLIAMSON
90%	619750	3379750	30.5441755869	-97.7515746343	WILLIAMSON
90%	619750	3392750	30.6614567290	-97.7500695340	WILLIAMSON
90%	621250	3380750	30.5530464246	-97.7358230118	WILLIAMSON
90%	621750	3317250	29.9800965746	-97.7379608816	CALDWELL
90%	621750	3407250	30.7920642439	-97.7274807538	WILLIAMSON
90%	622250	3369250	30.4491954704	-97.7267512888	WILLIAMSON
90%	622750	3376750	30.5168072238	-97.7206600654	WILLIAMSON
90%	622750	3402250	30.7468548479	-97.7176294009	WILLIAMSON

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
90%	623250	3386250	30.6024607920	-97.7143204305	WILLIAMSON
90%	624750	3368750	30.4444279977	-97.7007788877	TRAVIS
90%	624750	3372750	30.4805145739	-97.7002998275	WILLIAMSON
90%	628250	3387750	30.6154669310	-97.6619887376	WILLIAMSON
90%	628250	3396750	30.6966580309	-97.6608698256	WILLIAMSON
90%	628250	3397750	30.7056791992	-97.6607452212	WILLIAMSON
90%	630250	3410750	30.8227351315	-97.6382147814	WILLIAMSON
90%	630750	3412250	30.8362114151	-97.6327966777	WILLIAMSON
90%	631250	3339750	30.1821098926	-97.6367266214	TRAVIS
90%	631250	3340250	30.1866207892	-97.6366644923	TRAVIS
90%	631250	3394750	30.6782891501	-97.6298074691	WILLIAMSON
90%	631250	3412250	30.8361561300	-97.6275696306	WILLIAMSON
90%	631750	3340250	30.1865667060	-97.6314720719	TRAVIS
90%	631750	3358750	30.3534672547	-97.6291545926	TRAVIS
90%	631750	3395250	30.6827445300	-97.6245250172	WILLIAMSON
90%	632750	3341750	30.1999905059	-97.6208986730	TRAVIS
90%	632750	3342250	30.2045013603	-97.6208357776	TRAVIS
90%	633750	3342250	30.2043916766	-97.6104491437	TRAVIS
90%	635750	3342250	30.2041698421	-97.5896760487	TRAVIS
90%	637750	3294250	29.7708976185	-97.5751013359	CALDWELL
90%	643750	3370750	30.4603500851	-97.5026786860	TRAVIS
90%	643750	3371750	30.4693709622	-97.5025406695	TRAVIS
90%	645750	3381250	30.5548270026	-97.4803800235	WILLIAMSON
90%	649750	3341250	30.1935039010	-97.4444129645	BASTROP
90%	658250	3298750	29.8090388790	-97.3624540492	CALDWELL
90%	658250	3299250	29.8135494637	-97.3623805361	CALDWELL
90%	665250	3360750	30.3673884908	-97.2803932504	BASTROP
90%	670750	3322750	30.0238629470	-97.2293281528	BASTROP
90%	671750	3311250	29.9199898190	-97.2208122266	BASTROP
90%	671750	3322750	30.0237230123	-97.2189623627	BASTROP
90%	676750	3316250	29.9643811812	-97.1682116983	BASTROP
90%	684250	3330750	30.0940609230	-97.0880098349	BASTROP
90%	684250	3331250	30.0985706406	-97.0879230141	BASTROP
90%	684750	3326750	30.0579075818	-97.0835194241	BASTROP
90%	684750	3328750	30.0759464839	-97.0831717130	BASTROP
90%	685750	3327250	30.0622657099	-97.0730635773	BASTROP
90%	686250	3332750	30.1117959658	-97.0669141953	BASTROP
87%	571750	3322250	30.0291626768	-98.2558662369	HAYS
87%	571750	3322750	30.0336745786	-98.2558325297	HAYS
87%	575750	3332250	30.1191580930	-98.2136713509	HAYS
87%	575750	3336250	30.1552523691	-98.2133851437	HAYS
87%	576250	3315250	29.9657241943	-98.2097000704	HAYS
87%	576750	3350250	30.2815177860	-98.2019825315	HAYS
87%	577250	3330750	30.1055285957	-98.1982110667	HAYS
87%	579250	3354750	30.3219614280	-98.1756510451	HAYS
87%	582250	3331250	30.1097133640	-98.1462812298	HAYS
87%	582250	3355750	30.3307842192	-98.1443698407	HAYS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
87%	582750	3356750	30.3397732170	-98.1390899888	TRAVIS
87%	582750	3357750	30.3487963313	-98.1390110091	TRAVIS
87%	582750	3358250	30.3533078837	-98.1389715058	TRAVIS
87%	583750	3357250	30.3442158599	-98.1286472836	TRAVIS
87%	584750	3325250	30.0554015845	-98.1208138466	HAYS
87%	586750	3372750	30.4838593330	-98.0961499986	TRAVIS
87%	587250	3314750	29.9604792025	-98.0957415522	HAYS
87%	587250	3321250	30.0191319268	-98.0952098198	HAYS
87%	587250	3365750	30.4206631844	-98.0915271206	TRAVIS
87%	587750	3308250	29.9017903657	-98.0910933021	HAYS
87%	588750	3371250	30.4701790824	-98.0754421201	TRAVIS
87%	588750	3371750	30.4746904726	-98.0753994944	TRAVIS
87%	588750	3373750	30.4927360016	-98.0752288951	TRAVIS
87%	589250	3325750	30.0595928901	-98.0740943831	HAYS
87%	589250	3364250	30.4069823566	-98.0708330225	TRAVIS
87%	591750	3317750	29.9872210780	-98.0488509536	HAYS
87%	591750	3380750	30.5556689307	-98.0433540977	TRAVIS
87%	591750	3386250	30.6052929379	-98.0428667372	TRAVIS
87%	591750	3386750	30.6098041922	-98.0428223717	TRAVIS
87%	592250	3317750	29.9871835385	-98.0436681819	HAYS
87%	592750	3386250	30.6052157769	-98.0324360127	TRAVIS
87%	592750	3389750	30.6367943931	-98.0321218579	WILLIAMSON
87%	593750	3385750	30.6006265500	-98.0220506505	TRAVIS
87%	594250	3369750	30.4562264351	-98.0182881774	TRAVIS
87%	594250	3371250	30.4697603997	-98.0181524407	TRAVIS
87%	595250	3317250	29.9824423753	-98.0126164000	HAYS
87%	595250	3346750	30.2486239268	-98.0099651960	TRAVIS
87%	595250	3369750	30.4561476507	-98.0078734423	TRAVIS
87%	595250	3370250	30.4606589612	-98.0078277273	TRAVIS
87%	595750	3346750	30.2485845496	-98.0047688185	TRAVIS
87%	596250	3347250	30.2530564090	-97.9995267347	TRAVIS
87%	596250	3381750	30.5643382662	-97.9963471894	TRAVIS
87%	596750	3302750	29.8514864716	-97.9983795216	HAYS
87%	596750	3382750	30.5733203959	-97.9910407023	TRAVIS
87%	597750	3364750	30.4108341321	-97.9823053459	TRAVIS
87%	597750	3369250	30.4514357756	-97.9818836901	TRAVIS
87%	598250	3364750	30.4107934623	-97.9771004417	TRAVIS
87%	598250	3366250	30.4243273502	-97.9769592670	TRAVIS
87%	598250	3386750	30.6092876082	-97.9750202564	TRAVIS
87%	598750	3319750	30.0047233082	-97.9761078348	HAYS
87%	599750	3303750	29.8602705811	-97.9672327736	HAYS
87%	599750	3304750	29.8692939055	-97.9671398370	HAYS
87%	599750	3357250	30.3430006704	-97.9622009803	TRAVIS
87%	601250	3306750	29.8872179871	-97.9514214637	HAYS
87%	601750	3306750	29.8871767377	-97.9462440273	HAYS
87%	601750	3311250	29.9277811604	-97.9458165107	HAYS
87%	601750	3370250	30.4601265087	-97.9401298584	TRAVIS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
87%	602250	3356250	30.3337690793	-97.9362922555	TRAVIS
87%	602250	3370250	30.4600840962	-97.9349224058	TRAVIS
87%	602250	3371750	30.4736176996	-97.9347751211	TRAVIS
87%	603250	3305250	29.8735169749	-97.9308561912	HAYS
87%	603250	3305750	29.8780285768	-97.9308080661	HAYS
87%	603250	3307250	29.8915633637	-97.9306636251	HAYS
87%	603250	3307750	29.8960749530	-97.9306154562	HAYS
87%	603250	3315750	29.9682599524	-97.9298432655	HAYS
87%	603250	3377250	30.5231550030	-97.9238126243	TRAVIS
87%	603750	3315250	29.9637062222	-97.9247102473	HAYS
87%	603750	3411250	30.8298618372	-97.9151786569	WILLIAMSON
87%	604250	3363250	30.3967556030	-97.9147921257	TRAVIS
87%	604750	3348250	30.2613744621	-97.9110865477	TRAVIS
87%	604750	3359750	30.3651336977	-97.9099386338	TRAVIS
87%	604750	3363250	30.3967122605	-97.9095880815	TRAVIS
87%	605250	3322250	30.0267392488	-97.9084752886	HAYS
87%	605250	3360750	30.3741126495	-97.9046356945	TRAVIS
87%	605250	3362250	30.3876462958	-97.9044847411	TRAVIS
87%	605250	3374750	30.5004255635	-97.9032228068	TRAVIS
87%	605750	3374750	30.5003816257	-97.8980132723	TRAVIS
87%	605750	3400750	30.7349556791	-97.8953529398	WILLIAMSON
87%	606250	3365250	30.4146257179	-97.8937725820	TRAVIS
87%	606250	3387250	30.6131143520	-97.8915226162	WILLIAMSON
87%	606750	3384250	30.5860035803	-97.8866166608	WILLIAMSON
87%	607250	3366250	30.4235594172	-97.8832599391	TRAVIS
87%	607250	3384250	30.5859588662	-97.8814025852	WILLIAMSON
87%	607750	3372750	30.4821594033	-97.8773824428	TRAVIS
87%	607750	3378750	30.5362924185	-97.8767603012	TRAVIS
87%	608250	3323750	30.0400117324	-97.8772153002	HAYS
87%	608250	3370750	30.4640700484	-97.8723818929	TRAVIS
87%	608250	3413750	30.8520135117	-97.8678689712	WILLIAMSON
87%	608750	3363250	30.3963580589	-97.8679561403	TRAVIS
87%	608750	3370250	30.4595138245	-97.8672265509	TRAVIS
87%	608750	3372250	30.4775582136	-97.8670176723	TRAVIS
87%	608750	3372750	30.4820693029	-97.8669654231	TRAVIS
87%	609250	3370250	30.4594685029	-97.8620192585	TRAVIS
87%	609750	3329750	30.0940144063	-97.8610398516	HAYS
87%	609750	3334750	30.1391277075	-97.8605220777	TRAVIS
87%	609750	3350750	30.2834881303	-97.8588572973	TRAVIS
87%	609750	3363250	30.3962674359	-97.8575482716	TRAVIS
87%	609750	3364250	30.4052896940	-97.8574432295	TRAVIS
87%	609750	3364750	30.4098008183	-97.8573906905	TRAVIS
87%	609750	3365250	30.4143119393	-97.8573381398	TRAVIS
87%	609750	3369250	30.4504007924	-97.8569173055	TRAVIS
87%	609750	3373750	30.4910005070	-97.8564429564	TRAVIS
87%	610250	3351250	30.2879539148	-97.8536068835	TRAVIS
87%	610250	3351750	30.2924651140	-97.8535544149	TRAVIS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
87%	610250	3356250	30.3330657631	-97.8530816629	TRAVIS
87%	610250	3360750	30.3736661532	-97.8526079474	TRAVIS
87%	610250	3364750	30.4097551713	-97.8521860566	TRAVIS
87%	610250	3365250	30.4142662842	-97.8521332665	TRAVIS
87%	610750	3329250	30.0894127195	-97.8507160056	HAYS
87%	610750	3353750	30.3104642054	-97.8481450494	TRAVIS
87%	611250	3326250	30.0622992375	-97.8458425094	HAYS
87%	611250	3360750	30.3735743692	-97.8422025392	TRAVIS
87%	611250	3366750	30.4277076216	-97.8415636781	TRAVIS
87%	611250	3396750	30.6983669510	-97.8383432596	WILLIAMSON
87%	611750	3366250	30.4231502409	-97.8364116669	TRAVIS
87%	611750	3396750	30.6983201491	-97.8331232410	WILLIAMSON
87%	612250	3312250	29.9358893600	-97.8369438986	HAYS
87%	612250	3405250	30.7749575564	-97.8269745575	WILLIAMSON
87%	612750	3311750	29.9313321422	-97.8318168506	HAYS
87%	612750	3378750	30.5358326109	-97.8246468307	WILLIAMSON
87%	612750	3379250	30.5403435923	-97.8245925018	WILLIAMSON
87%	613250	3355250	30.3237661306	-97.8219864620	TRAVIS
87%	613250	3355750	30.3282772544	-97.8219324691	TRAVIS
87%	613250	3378250	30.5312745077	-97.8194901076	WILLIAMSON
87%	613250	3378750	30.5357854839	-97.8194355502	WILLIAMSON
87%	613250	3379250	30.5402964569	-97.8193809806	WILLIAMSON
87%	613250	3381250	30.5583403169	-97.8191625786	WILLIAMSON
87%	613750	3364750	30.4094298367	-97.8157539559	TRAVIS
87%	613750	3377750	30.5267162098	-97.8143338658	WILLIAMSON
87%	613750	3378250	30.5312271808	-97.8142790801	WILLIAMSON
87%	614250	3378250	30.5311796456	-97.8090680651	WILLIAMSON
87%	614750	3380750	30.5536866233	-97.8035805405	WILLIAMSON
87%	615250	3372750	30.4814633744	-97.7992559660	WILLIAMSON
87%	615250	3378250	30.5310839500	-97.7986460723	WILLIAMSON
87%	615750	3373250	30.4859262777	-97.7939920100	WILLIAMSON
87%	615750	3373750	30.4904372434	-97.7939363751	WILLIAMSON
87%	615750	3378250	30.5310357897	-97.7934350947	WILLIAMSON
87%	616750	3352250	30.2963667741	-97.7859203192	TRAVIS
87%	616750	3389750	30.6346891002	-97.7817163896	WILLIAMSON
87%	616750	3396750	30.6978405945	-97.7809237377	WILLIAMSON
87%	617250	3360750	30.3730062722	-97.7797711154	TRAVIS
87%	617250	3389750	30.6346401138	-97.7764999007	WILLIAMSON
87%	617250	3394250	30.6752374968	-97.7759884470	WILLIAMSON
87%	617750	3354750	30.3188251999	-97.7752429039	TRAVIS
87%	618250	3331750	30.1112650628	-97.7726221512	TRAVIS
87%	618250	3387750	30.6164982186	-97.7662958751	WILLIAMSON
87%	619250	3395250	30.6840606751	-97.7549981659	WILLIAMSON
87%	619250	3395750	30.6885714374	-97.7549402778	WILLIAMSON
87%	619750	3393250	30.6659674985	-97.7500114689	WILLIAMSON
87%	619750	3395250	30.6840105443	-97.7497790776	WILLIAMSON
87%	620250	3369250	30.4493970441	-97.7475773167	WILLIAMSON

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
87%	620250	3375250	30.5035277785	-97.7468841555	WILLIAMSON
87%	620750	3369250	30.4493469622	-97.7423707900	TRAVIS
87%	621250	3369250	30.4492966726	-97.7371642765	TRAVIS
87%	621250	3392250	30.6567944687	-97.7344747615	WILLIAMSON
87%	621750	3368250	30.4402243952	-97.7320745578	TRAVIS
87%	621750	3369250	30.4492461753	-97.7319577760	TRAVIS
87%	621750	3373750	30.4898440260	-97.7314316043	WILLIAMSON
87%	621750	3374250	30.4943548822	-97.7313730746	WILLIAMSON
87%	622250	3374250	30.4943040864	-97.7261641882	WILLIAMSON
87%	622250	3389250	30.6296279972	-97.7243949080	WILLIAMSON
87%	622250	3392250	30.6566924302	-97.7240396115	WILLIAMSON
87%	622250	3392750	30.6612031577	-97.7239803486	WILLIAMSON
87%	622750	3316750	29.9754856392	-97.7276546909	CALDWELL
87%	622750	3367250	30.4311010577	-97.7217802419	TRAVIS
87%	622750	3374750	30.4987639172	-97.7208962919	WILLIAMSON
87%	622750	3375250	30.5032747487	-97.7208372553	WILLIAMSON
87%	622750	3375750	30.5077855770	-97.7207782053	WILLIAMSON
87%	622750	3386250	30.6025122243	-97.7195350703	WILLIAMSON
87%	622750	3386750	30.6070229815	-97.7194757263	WILLIAMSON
87%	622750	3389250	30.6295767188	-97.7191788048	WILLIAMSON
87%	622750	3389750	30.6340874566	-97.7191193803	WILLIAMSON
87%	622750	3392750	30.6611518152	-97.7187625514	WILLIAMSON
87%	623250	3365250	30.4130064590	-97.7168109109	TRAVIS
87%	623250	3386750	30.6069715400	-97.7142608450	WILLIAMSON
87%	623250	3394750	30.6791430674	-97.7133056440	WILLIAMSON
87%	623750	3349250	30.2686055231	-97.7134957064	TRAVIS
87%	623750	3397750	30.7061553226	-97.7077263586	WILLIAMSON
87%	624250	3387250	30.6113787563	-97.7037710406	WILLIAMSON
87%	624750	3387750	30.6158373924	-97.6984956209	WILLIAMSON
87%	625250	3387250	30.6112743920	-97.6933408895	WILLIAMSON
87%	625750	3382750	30.5706254959	-97.6886726022	WILLIAMSON
87%	626250	3346750	30.2457929252	-97.6878112892	TRAVIS
87%	626250	3363750	30.3991633202	-97.6857652139	TRAVIS
87%	626250	3383250	30.5750835907	-97.6833987946	WILLIAMSON
87%	627250	3379250	30.5388920492	-97.6734635906	WILLIAMSON
87%	628250	3283750	29.6771828514	-97.6745931869	CALDWELL
87%	628250	3352750	30.2997137871	-97.6662970722	TRAVIS
87%	628250	3382750	30.5703603100	-97.6626083937	WILLIAMSON
87%	628250	3383250	30.5748709867	-97.6625464911	WILLIAMSON
87%	628250	3397250	30.7011686167	-97.6608075304	WILLIAMSON
87%	628750	3376750	30.5161783890	-97.6581402254	WILLIAMSON
87%	628750	3399250	30.7191569471	-97.6553374241	WILLIAMSON
87%	630250	3410250	30.8182246724	-97.6382784334	WILLIAMSON
87%	630750	3315750	29.9656364730	-97.6448732332	CALDWELL
87%	631250	3410250	30.8181143916	-97.6278262784	WILLIAMSON
87%	631250	3415750	30.8677290465	-97.6271199400	WILLIAMSON
87%	632750	3281250	29.6541534096	-97.6284046945	CALDWELL

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
87%	633250	3365250	30.4119419792	-97.6127228791	TRAVIS
87%	634750	3368250	30.4388390820	-97.5967227954	TRAVIS
87%	635750	3286250	29.6989408278	-97.5967894644	CALDWELL
87%	636750	3341250	30.1950361390	-97.5794191507	TRAVIS
87%	637250	3341250	30.1949797755	-97.5742264158	TRAVIS
87%	637750	3341250	30.1949232065	-97.5690336955	TRAVIS
87%	637750	3393250	30.6640245988	-97.5621683430	WILLIAMSON
87%	638250	3296250	29.7888859817	-97.5696741349	CALDWELL
87%	638750	3391750	30.6503774867	-97.5519349223	WILLIAMSON
87%	639250	3385250	30.5916837826	-97.5475939362	WILLIAMSON
87%	639250	3392750	30.6593400488	-97.5465831062	WILLIAMSON
87%	639750	3347750	30.2533339338	-97.5474012799	TRAVIS
87%	639750	3385250	30.5916254779	-97.5423802517	WILLIAMSON
87%	640750	3351250	30.2847927698	-97.5365414860	TRAVIS
87%	641250	3343250	30.2125641896	-97.5324173676	TRAVIS
87%	642750	3330750	30.0996217432	-97.5185236469	BASTROP
87%	642750	3349250	30.2665162787	-97.5160236735	TRAVIS
87%	643250	3325250	30.0499451030	-97.5140778363	BASTROP
87%	643250	3325750	30.0544558495	-97.5140104774	BASTROP
87%	643250	3333250	30.1221166580	-97.5129982584	BASTROP
87%	643750	3325750	30.0543971437	-97.5088252442	BASTROP
87%	650250	3395750	30.6850664216	-97.4313686377	WILLIAMSON
87%	650250	3396250	30.6895765552	-97.4312957024	WILLIAMSON
87%	651250	3302250	29.8414916329	-97.4343736859	CALDWELL
87%	651250	3302750	29.8460023543	-97.4343033084	CALDWELL
87%	653250	3348250	30.2562132682	-97.4070493529	BASTROP
87%	653250	3371250	30.4636872373	-97.4036829988	WILLIAMSON
87%	655250	3311750	29.9266958007	-97.3916068084	BASTROP
87%	658250	3344750	30.2239990390	-97.3556205352	BASTROP
87%	658250	3345750	30.2330196050	-97.3554703924	BASTROP
87%	660250	3296750	29.7907386660	-97.3420631435	CALDWELL
87%	660250	3384250	30.5800353052	-97.3287877156	WILLIAMSON
87%	661250	3328750	30.0792757028	-97.3268968895	BASTROP
87%	661750	3303250	29.8491796071	-97.3255725072	BASTROP
87%	661750	3328750	30.0792095705	-97.3217108321	BASTROP
87%	662750	3302750	29.8445374979	-97.3153000203	BASTROP
87%	665750	3333250	30.1192649197	-97.2795199376	BASTROP
87%	665750	3333750	30.1237750998	-97.2794417312	BASTROP
87%	666250	3301250	29.8305392794	-97.2793153915	BASTROP
87%	666250	3333750	30.1237070045	-97.2742534780	BASTROP
87%	667250	3303250	29.8484454659	-97.2686581285	BASTROP
87%	667250	3334750	30.1325904757	-97.2637191453	BASTROP
87%	667750	3302750	29.8438671796	-97.2635622601	BASTROP
87%	667750	3334750	30.1325217411	-97.2585304744	BASTROP
87%	668250	3379750	30.5383493387	-97.2461199105	WILLIAMSON
87%	668250	3380250	30.5428591496	-97.2460388389	WILLIAMSON
87%	668750	3380250	30.5427888656	-97.2408285368	WILLIAMSON

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
87%	668750	3380750	30.5472986606	-97.2407472062	WILLIAMSON
87%	670250	3336250	30.1457051599	-97.2323461929	BASTROP
87%	670750	3308250	29.8930679020	-97.2316454560	BASTROP
87%	671750	3311750	29.9244999939	-97.2207319983	BASTROP
87%	672250	3307250	29.8838384209	-97.2162777700	BASTROP
87%	672250	3311750	29.9244299999	-97.2155542737	BASTROP
87%	674750	3314750	29.9511375030	-97.1891757729	BASTROP
87%	677250	3317250	29.9733290357	-97.1628660773	BASTROP
87%	681750	3329250	30.0809064312	-97.1141976894	BASTROP
87%	683250	3329750	30.0851919907	-97.0985548329	BASTROP
87%	685750	3327750	30.0667754097	-97.0729761898	BASTROP
87%	686250	3333250	30.1163056152	-97.0668263544	BASTROP
87%	687750	3329250	30.0799986126	-97.0519724921	BASTROP
87%	689250	3326250	30.0527094525	-97.0369508848	BASTROP
84%	569750	3326750	30.0698855421	-98.2763120601	HAYS
84%	570250	3327250	30.0743687732	-98.2710916126	HAYS
84%	573250	3333250	30.1283345401	-98.2395517019	HAYS
84%	573250	3336750	30.1599171918	-98.2393094506	HAYS
84%	574250	3333250	30.1282740118	-98.2291709363	HAYS
84%	574750	3335250	30.1462906226	-98.2238393504	HAYS
84%	575250	3332250	30.1191890640	-98.2188612340	HAYS
84%	575750	3331250	30.1101344926	-98.2137428217	HAYS
84%	575750	3334750	30.1417170391	-98.2134925322	HAYS
84%	575750	3335250	30.1462288189	-98.2134567441	HAYS
84%	576750	3330750	30.1055601646	-98.2034002179	HAYS
84%	576750	3332250	30.1190955361	-98.2032916093	HAYS
84%	576750	3332750	30.1236073203	-98.2032553900	HAYS
84%	577250	3330250	30.1010168046	-98.1982474888	HAYS
84%	577250	3332750	30.1235757285	-98.1980652956	HAYS
84%	577750	3325250	30.0558670103	-98.1934247027	HAYS
84%	577750	3329750	30.0964732480	-98.1930952310	HAYS
84%	577750	3330250	30.1009850364	-98.1930585815	HAYS
84%	577750	3352250	30.2995006152	-98.1914377562	HAYS
84%	578250	3333750	30.1325354543	-98.1876112526	HAYS
84%	578750	3333250	30.1279914808	-98.1824578909	HAYS
84%	579250	3339750	30.1866115550	-98.1767805291	HAYS
84%	580250	3325250	30.0557053885	-98.1674920599	HAYS
84%	580250	3331250	30.1098466314	-98.1670384899	HAYS
84%	580750	3325750	30.0601842321	-98.1622675713	HAYS
84%	580750	3359750	30.3669779926	-98.1596642617	TRAVIS
84%	581250	3360750	30.3759675485	-98.1543837647	TRAVIS
84%	581750	3325250	30.0556059611	-98.1519325765	HAYS
84%	582250	3330750	30.1052016351	-98.1463200172	HAYS
84%	584250	3355750	30.3306464619	-98.1235662626	TRAVIS
84%	585250	3364750	30.4117834672	-98.1124312495	TRAVIS
84%	585750	3309750	29.9154669430	-98.1116869149	HAYS
84%	585750	3375750	30.5109996002	-98.1063205274	TRAVIS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
84%	585750	3377750	30.5290451837	-98.1061553941	TRAVIS
84%	586750	3308750	29.9063731394	-98.1014096505	HAYS
84%	586750	3366250	30.4252107553	-98.0966911617	TRAVIS
84%	586750	3367250	30.4342336483	-98.0966080093	TRAVIS
84%	586750	3367750	30.4387450900	-98.0965664190	TRAVIS
84%	586750	3377750	30.5289732584	-98.0957326360	TRAVIS
84%	587250	3368750	30.4477318056	-98.0912761695	TRAVIS
84%	588250	3367250	30.4341246084	-98.0809890725	TRAVIS
84%	589250	3368250	30.4430736918	-98.0704909094	TRAVIS
84%	592750	3353750	30.3119783160	-98.0353295588	TRAVIS
84%	593750	3301250	29.8381831121	-98.0295646336	HAYS
84%	594250	3351750	30.2938166284	-98.0199098549	TRAVIS
84%	594750	3301250	29.8381066564	-98.0192145816	HAYS
84%	594750	3371250	30.4697210902	-98.0129443483	TRAVIS
84%	595250	3351750	30.2937383516	-98.0095123170	TRAVIS
84%	595750	3301750	29.8425411268	-98.0088200193	HAYS
84%	595750	3302250	29.8470528608	-98.0087754590	HAYS
84%	596250	3391750	30.6545620543	-97.9954162760	WILLIAMSON
84%	596250	3398750	30.7177179448	-97.9947621316	WILLIAMSON
84%	596750	3388750	30.6274546588	-97.9904795081	WILLIAMSON
84%	596750	3399750	30.7266996115	-97.9894466955	WILLIAMSON
84%	598250	3319750	30.0047635279	-97.9812914123	HAYS
84%	598250	3404250	30.7671762587	-97.9733507413	WILLIAMSON
84%	598750	3389250	30.6318021325	-97.9695658781	WILLIAMSON
84%	598750	3399250	30.7220242313	-97.9686075595	WILLIAMSON
84%	599250	3398750	30.7174715694	-97.9634342998	WILLIAMSON
84%	599250	3399250	30.7219826365	-97.9633860381	WILLIAMSON
84%	599250	3407750	30.7986702861	-97.9625639212	WILLIAMSON
84%	599750	3398250	30.7129187092	-97.9582615260	WILLIAMSON
84%	600250	3398250	30.7128767094	-97.9530405124	WILLIAMSON
84%	600250	3403250	30.7579871185	-97.9525526503	WILLIAMSON
84%	600250	3405250	30.7760311922	-97.9523571972	WILLIAMSON
84%	600250	3406250	30.7850532098	-97.9522594044	WILLIAMSON
84%	600250	3407250	30.7940752146	-97.9521615676	WILLIAMSON
84%	600750	3317250	29.9820026017	-97.9556098234	HAYS
84%	600750	3403250	30.7579448335	-97.9473292159	WILLIAMSON
84%	600750	3404750	30.7714778710	-97.9471819119	WILLIAMSON
84%	601250	3317750	29.9864729553	-97.9503800192	HAYS
84%	601750	3406750	30.7894365689	-97.9365351050	WILLIAMSON
84%	602250	3310250	29.9187164724	-97.9407325317	HAYS
84%	602250	3310750	29.9232280579	-97.9406847640	HAYS
84%	602250	3398750	30.7172176363	-97.9321068599	WILLIAMSON
84%	602250	3405750	30.7803716491	-97.9314097634	WILLIAMSON
84%	602750	3312250	29.9367210569	-97.9353614146	HAYS
84%	602750	3313750	29.9502557434	-97.9352172478	HAYS
84%	602750	3315750	29.9683019477	-97.9350248727	HAYS
84%	602750	3398750	30.7171745794	-97.9268856588	WILLIAMSON

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
84%	602750	3407750	30.7983723418	-97.9259846054	WILLIAMSON
84%	603250	3311250	29.9276559898	-97.9302779678	HAYS
84%	603250	3315250	29.9637484136	-97.9298916096	HAYS
84%	603250	3386750	30.6088661962	-97.9228660104	WILLIAMSON
84%	603250	3389750	30.6359326485	-97.9225662350	WILLIAMSON
84%	603250	3398750	30.7171313125	-97.9216644690	WILLIAMSON
84%	603250	3410250	30.8208836464	-97.9205068709	WILLIAMSON
84%	603750	3314750	29.9591946879	-97.9247588143	HAYS
84%	604250	3406750	30.7892196168	-97.9104096853	WILLIAMSON
84%	604250	3407250	30.7937305562	-97.9103588105	WILLIAMSON
84%	604750	3319750	30.0042247556	-97.9139057408	HAYS
84%	604750	3321250	30.0177592077	-97.9137582685	HAYS
84%	604750	3405750	30.7801537220	-97.9052868383	WILLIAMSON
84%	605250	3320250	30.0086933627	-97.9086729234	HAYS
84%	605250	3337250	30.1620817770	-97.9069873003	HAYS
84%	605250	3397250	30.7034232011	-97.9009332868	WILLIAMSON
84%	605750	3301750	29.8417237184	-97.9053175455	HAYS
84%	606250	3313750	29.9499577131	-97.8989527781	HAYS
84%	606250	3314250	29.9544692150	-97.8989030640	HAYS
84%	606250	3394250	30.6762685246	-97.8908020165	WILLIAMSON
84%	606250	3413750	30.8521946819	-97.8887825886	WILLIAMSON
84%	606750	3341750	30.2025531010	-97.8909575884	TRAVIS
84%	606750	3406750	30.7889974017	-97.8842845525	WILLIAMSON
84%	606750	3414250	30.8566605606	-97.8835019078	WILLIAMSON
84%	607250	3306750	29.8867095913	-97.8892929499	CALDWELL
84%	607250	3308250	29.9002441731	-97.8891428486	HAYS
84%	607250	3387250	30.6130250371	-97.8810915551	WILLIAMSON
84%	607250	3406750	30.7889523272	-97.8790595609	WILLIAMSON
84%	607250	3414750	30.8611262089	-97.8782207378	WILLIAMSON
84%	607750	3317250	29.9814072125	-97.8830578823	HAYS
84%	607750	3406750	30.7889070421	-97.8738345811	WILLIAMSON
84%	607750	3412250	30.8385265857	-97.8732555301	WILLIAMSON
84%	608250	3346250	30.2430218887	-97.8749142670	TRAVIS
84%	608250	3354750	30.3197129355	-97.8740388665	TRAVIS
84%	608250	3405750	30.7798397857	-97.8687152285	WILLIAMSON
84%	608750	3321250	30.0174103263	-97.8722854643	HAYS
84%	608750	3323750	30.0399673677	-97.8720300662	HAYS
84%	608750	3405250	30.7752832187	-97.8635437935	WILLIAMSON
84%	609250	3323750	30.0399227985	-97.8668448438	HAYS
84%	609250	3325750	30.0579683422	-97.8666393770	HAYS
84%	609250	3334250	30.1346613353	-97.8657640616	HAYS
84%	609750	3389250	30.6308419788	-97.8548016853	WILLIAMSON
84%	610250	3335250	30.1435938551	-97.8552796217	TRAVIS
84%	610750	3312750	29.9405370034	-97.8524314470	HAYS
84%	610750	3388750	30.6262387207	-97.8444224634	WILLIAMSON
84%	611250	3312750	29.9404917973	-97.8472514245	HAYS
84%	611250	3326750	30.0668105796	-97.8457901615	HAYS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
84%	611250	3400750	30.7344539865	-97.8379105652	WILLIAMSON
84%	611750	3312750	29.9404463877	-97.8420714138	HAYS
84%	611750	3388250	30.6216346560	-97.8340442451	WILLIAMSON
84%	612250	3414750	30.8606625673	-97.8259324025	WILLIAMSON
84%	612250	3415250	30.8651733250	-97.8258774285	WILLIAMSON
84%	612750	3312250	29.9358435517	-97.8317641453	HAYS
84%	612750	3373250	30.4862116028	-97.8252436393	WILLIAMSON
84%	612750	3413250	30.8470827749	-97.8208692176	WILLIAMSON
84%	613750	3379250	30.5402491131	-97.8141694717	WILLIAMSON
84%	613750	3380250	30.5492710325	-97.8140598137	WILLIAMSON
84%	613750	3390250	30.6394895190	-97.8129605059	WILLIAMSON
84%	613750	3390750	30.6440004095	-97.8129054101	WILLIAMSON
84%	614250	3375250	30.5041138225	-97.8093980363	WILLIAMSON
84%	614250	3379250	30.5402015608	-97.8089579752	WILLIAMSON
84%	614250	3390750	30.6439526613	-97.8076883615	WILLIAMSON
84%	614250	3391250	30.6484635400	-97.8076330112	WILLIAMSON
84%	614250	3391750	30.6529744156	-97.8075776484	WILLIAMSON
84%	614750	3311250	29.9266355288	-97.8111525190	CALDWELL
84%	614750	3374750	30.4995551570	-97.8042436687	WILLIAMSON
84%	614750	3391250	30.6484155740	-97.8024157330	WILLIAMSON
84%	615250	3375250	30.5040182297	-97.7989789295	WILLIAMSON
84%	615250	3375750	30.5085291911	-97.7989234846	WILLIAMSON
84%	615250	3379250	30.5401058310	-97.7985350196	WILLIAMSON
84%	615250	3381250	30.5581495545	-97.7983127636	WILLIAMSON
84%	616250	3378250	30.5309874211	-97.7882241297	WILLIAMSON
84%	616250	3378750	30.5354983459	-97.7881681282	WILLIAMSON
84%	616250	3403750	30.7610404770	-97.7853518744	WILLIAMSON
84%	616750	3378750	30.5354497602	-97.7829569352	WILLIAMSON
84%	616750	3404250	30.7655022071	-97.7800716848	WILLIAMSON
84%	618250	3318250	29.9894617735	-97.7741233886	HAYS
84%	618250	3400250	30.7292679632	-97.7648617678	WILLIAMSON
84%	618750	3355250	30.3232384476	-97.7647869890	TRAVIS
84%	619750	3354250	30.3141177869	-97.7545013891	TRAVIS
84%	619750	3354750	30.3186288046	-97.7544443256	TRAVIS
84%	619750	3373250	30.4855341977	-97.7523238768	WILLIAMSON
84%	620250	3402750	30.7516210299	-97.7436830209	WILLIAMSON
84%	620750	3297250	29.7997434122	-97.7505774516	CALDWELL
84%	621750	3362250	30.3860934443	-97.7327741407	TRAVIS
84%	622250	3370250	30.4582172194	-97.7266339748	WILLIAMSON
84%	622750	3335750	30.1469091401	-97.7254602558	TRAVIS
84%	623750	3337750	30.1648521560	-97.7148452337	TRAVIS
84%	623750	3346250	30.2415395911	-97.7138484348	TRAVIS
84%	624250	3320750	30.0114238637	-97.7116439078	CALDWELL
84%	624250	3346750	30.2459994673	-97.7085939750	TRAVIS
84%	624750	3370750	30.4624713117	-97.7005394659	WILLIAMSON
84%	625250	3372250	30.4759517565	-97.6951519118	WILLIAMSON
84%	626750	3325250	30.0517674134	-97.6851910311	TRAVIS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
84%	626750	3325750	30.0562784892	-97.6851314231	TRAVIS
84%	627250	3322750	30.0291600815	-97.6803045679	CALDWELL
84%	627750	3382750	30.5704137645	-97.6678212077	WILLIAMSON
84%	627750	3383250	30.5749244507	-97.6677595461	WILLIAMSON
84%	627750	3383750	30.5794351337	-97.6676978706	WILLIAMSON
84%	628250	3383750	30.5793816602	-97.6624845744	WILLIAMSON
84%	628250	3401750	30.7417637425	-97.6602462413	WILLIAMSON
84%	628750	3382250	30.5657959766	-97.6574577235	WILLIAMSON
84%	628750	3382750	30.5703066469	-97.6573955938	WILLIAMSON
84%	629250	3385750	30.5973166713	-97.6518082872	WILLIAMSON
84%	629250	3408250	30.8002921634	-97.6489831588	WILLIAMSON
84%	629750	3388250	30.6198156420	-97.6462803719	WILLIAMSON
84%	629750	3407250	30.7912166150	-97.6438846801	WILLIAMSON
84%	629750	3407750	30.7957271034	-97.6438213579	WILLIAMSON
84%	630250	3318250	29.9882449914	-97.6497490749	CALDWELL
84%	630250	3366250	30.4212915307	-97.6438239447	TRAVIS
84%	630750	3410750	30.8226800867	-97.6329884526	WILLIAMSON
84%	631250	3311250	29.9249834674	-97.6402448058	CALDWELL
84%	631250	3362250	30.3850970497	-97.6339168410	TRAVIS
84%	631250	3363250	30.3941185493	-97.6337912967	TRAVIS
84%	631750	3372250	30.4752567543	-97.6274511753	TRAVIS
84%	631750	3414250	30.8541422807	-97.6220847412	WILLIAMSON
84%	632250	3341250	30.1955341620	-97.6261544192	TRAVIS
84%	632250	3394750	30.6781786389	-97.6193704513	WILLIAMSON
84%	632750	3281750	29.6586646519	-97.6283435028	CALDWELL
84%	632750	3370750	30.4616147223	-97.6172271103	TRAVIS
84%	632750	3371250	30.4661253892	-97.6171633842	TRAVIS
84%	632750	3371750	30.4706360528	-97.6170996438	TRAVIS
84%	632750	3394750	30.6781230690	-97.6141519641	WILLIAMSON
84%	633750	3366250	30.4209079404	-97.6073905186	TRAVIS
84%	635250	3282250	29.6629060698	-97.6024559107	CALDWELL
84%	635250	3283250	29.6719284403	-97.6023311540	CALDWELL
84%	635250	3286750	29.7035066364	-97.6018940587	CALDWELL
84%	636250	3341250	30.1950922970	-97.5846119004	TRAVIS
84%	637250	3293250	29.7619310837	-97.5803992902	CALDWELL
84%	637250	3342750	30.2085120685	-97.5740313402	TRAVIS
84%	637750	3297750	29.8024749709	-97.5746539379	CALDWELL
84%	638250	3392750	30.6594563430	-97.5570177716	WILLIAMSON
84%	638250	3393250	30.6639667554	-97.5569507454	WILLIAMSON
84%	639250	3391750	30.6503192557	-97.5467180813	WILLIAMSON
84%	639750	3392750	30.6592815876	-97.5413657963	WILLIAMSON
84%	640250	3324250	30.0412713549	-97.5453200005	BASTROP
84%	640750	3348750	30.2622395681	-97.5368761034	TRAVIS
84%	641750	3369250	30.4470560284	-97.5237091605	TRAVIS
84%	641750	3381750	30.5598173633	-97.5220046556	WILLIAMSON
84%	642750	3310250	29.9146793815	-97.5212695115	CALDWELL
84%	643250	3372250	30.4739410922	-97.5076789443	TRAVIS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
84%	643250	3372750	30.4784515333	-97.5076101369	TRAVIS
84%	643250	3386750	30.6047425583	-97.5056772055	WILLIAMSON
84%	643750	3348750	30.2618874906	-97.5056993144	TRAVIS
84%	643750	3378750	30.5325167365	-97.5015728051	WILLIAMSON
84%	643750	3379250	30.5370271244	-97.5015035548	WILLIAMSON
84%	644250	3304750	29.8648849933	-97.5064756235	CALDWELL
84%	644250	3342750	30.2077009631	-97.5013246829	TRAVIS
84%	644250	3378750	30.5324566927	-97.4963623916	WILLIAMSON
84%	644750	3378250	30.5278860709	-97.4912217096	WILLIAMSON
84%	644750	3378750	30.5323964406	-97.4911519938	WILLIAMSON
84%	644750	3379750	30.5414171702	-97.4910125150	WILLIAMSON
84%	645250	3286250	29.6978642513	-97.4986177302	CALDWELL
84%	645250	3342750	30.2075818012	-97.4909382618	BASTROP
84%	645250	3377250	30.5188048939	-97.4861514332	WILLIAMSON
84%	645250	3378250	30.5278256214	-97.4860115680	WILLIAMSON
84%	646750	3379250	30.5366636726	-97.4702398667	WILLIAMSON
84%	647250	3365750	30.4148227974	-97.4669389215	TRAVIS
84%	647250	3378750	30.5320920563	-97.4651002420	WILLIAMSON
84%	648250	3288250	29.7155527154	-97.4673432295	CALDWELL
84%	648250	3288750	29.7200635933	-97.4672746836	CALDWELL
84%	648250	3289250	29.7245744679	-97.4672061222	CALDWELL
84%	648750	3377250	30.5183760706	-97.4496842537	WILLIAMSON
84%	649750	3379750	30.5408029754	-97.4389046001	WILLIAMSON
84%	651750	3348750	30.2609123550	-97.4225639630	BASTROP
84%	653250	3332250	30.1118794709	-97.4093705822	BASTROP
84%	653250	3390750	30.6395836418	-97.4008013751	WILLIAMSON
84%	654250	3354250	30.3102104927	-97.3957777903	BASTROP
84%	654750	3332250	30.1116900373	-97.3938067112	BASTROP
84%	654750	3370750	30.4589849322	-97.3881378081	WILLIAMSON
84%	655250	3330750	30.0980951555	-97.3888383659	BASTROP
84%	656250	3335250	30.1385611898	-97.3778005558	BASTROP
84%	657750	3343250	30.2105332054	-97.3610386386	BASTROP
84%	657750	3350250	30.2736771942	-97.3599902432	BASTROP
84%	658250	3342750	30.2059578676	-97.3559206168	BASTROP
84%	658250	3344250	30.2194887510	-97.3556955810	BASTROP
84%	658250	3348750	30.2600812245	-97.3550195561	BASTROP
84%	658750	3343750	30.2149132024	-97.3505773735	BASTROP
84%	658750	3344250	30.2194234818	-97.3505021079	BASTROP
84%	658750	3344750	30.2239337580	-97.3504268252	BASTROP
84%	660250	3295750	29.7817175546	-97.3422118393	CALDWELL
84%	661250	3349250	30.2641960721	-97.3237695550	BASTROP
84%	662250	3303250	29.8491138800	-97.3203983862	BASTROP
84%	662750	3298250	29.8039432801	-97.3159808881	BASTROP
84%	663250	3297250	29.7948563186	-97.3109607010	BASTROP
84%	663250	3298750	29.8083877374	-97.3107333073	BASTROP
84%	663750	3297750	29.7993005922	-97.3057134036	BASTROP
84%	663750	3298250	29.8038110531	-97.3056373739	BASTROP

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
84%	663750	3298750	29.8083215107	-97.3055613270	BASTROP
84%	663750	3299250	29.8128319651	-97.3054852627	BASTROP
84%	664250	3392250	30.6516507736	-97.2858170042	WILLIAMSON
84%	666750	3304750	29.8620442653	-97.2735991805	BASTROP
84%	666750	3322750	30.0244145256	-97.2707920360	BASTROP
84%	669250	3309750	29.9068059456	-97.2469370355	BASTROP
84%	669250	3380750	30.5472281557	-97.2355366819	WILLIAMSON
84%	669250	3381250	30.5517379348	-97.2354550923	WILLIAMSON
84%	669250	3381750	30.5562477106	-97.2353734843	WILLIAMSON
84%	669750	3382250	30.5606867318	-97.2300806300	WILLIAMSON
84%	671250	3307250	29.8839779781	-97.2266290443	BASTROP
84%	671250	3313750	29.9426105025	-97.2255895789	BASTROP
84%	672250	3315750	29.9605111800	-97.2149099241	BASTROP
84%	672750	3315750	29.9604408810	-97.2097303506	BASTROP
84%	673750	3352250	30.2895278982	-97.1933856921	BASTROP
84%	675250	3353250	30.2983313569	-97.1776287995	BASTROP
84%	675250	3353750	30.3028411648	-97.1775453663	BASTROP
84%	675250	3354750	30.3118607705	-97.1773784431	BASTROP
84%	675750	3312250	29.9284444218	-97.1792286034	BASTROP
84%	675750	3323750	30.0321751046	-97.1773348733	BASTROP
84%	676250	3323250	30.0275931931	-97.1722344612	BASTROP
84%	677750	3312750	29.9326666870	-97.1584344111	BASTROP
84%	678750	3322750	30.0227206244	-97.1464039036	BASTROP
84%	679750	3324250	30.0361038279	-97.1357854600	BASTROP
84%	680250	3323750	30.0315203795	-97.1306868594	BASTROP
84%	680750	3322750	30.0224268854	-97.1256735939	BASTROP
84%	682250	3328750	30.0763221189	-97.1090979507	BASTROP
84%	682250	3347750	30.2476916139	-97.1058237595	BASTROP
84%	683250	3323250	30.0265649207	-97.0996751021	BASTROP
84%	683750	3344250	30.2158978821	-97.0908512934	BASTROP
84%	685250	3325750	30.0488124528	-97.0785093813	BASTROP
81%	571750	3334250	30.1374474568	-98.2550551495	HAYS
81%	573250	3335250	30.1463817885	-98.2394133196	HAYS
81%	573250	3335750	30.1508935928	-98.2393787045	HAYS
81%	573750	3337750	30.1689105677	-98.2340476528	HAYS
81%	576250	3331750	30.1146151241	-98.2085174513	HAYS
81%	577750	3353750	30.3130355462	-98.1913266562	HAYS
81%	579250	3356250	30.3354962591	-98.1755376743	HAYS
81%	579750	3339750	30.1865788554	-98.1715871687	HAYS
81%	579750	3340250	30.1910905577	-98.1715494061	HAYS
81%	579750	3356250	30.3354633647	-98.1703364755	HAYS
81%	580250	3314750	29.9609571252	-98.1682828434	HAYS
81%	580250	3359750	30.3670113425	-98.1648671135	TRAVIS
81%	581750	3341250	30.1999810264	-98.1506976592	HAYS
81%	582750	3311250	29.9292081713	-98.1426459807	HAYS
81%	582750	3311750	29.9337200166	-98.1426073013	HAYS
81%	583250	3311250	29.9291743824	-98.1374660827	HAYS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
81%	583250	3311750	29.9336862216	-98.1374271696	HAYS
81%	583250	3336250	30.1547624938	-98.1355095740	HAYS
81%	583250	3341250	30.1998791719	-98.1351156042	HAYS
81%	583250	3361250	30.3803427279	-98.1335307743	TRAVIS
81%	583750	3311750	29.9336522231	-98.1322470468	HAYS
81%	583750	3332750	30.1231463739	-98.1305948395	HAYS
81%	584750	3329250	30.0914953573	-98.1204946622	HAYS
81%	584750	3356750	30.3396345828	-98.1182845394	TRAVIS
81%	584750	3362250	30.3892612808	-98.1178392033	TRAVIS
81%	585750	3311750	29.9335141939	-98.1115266448	HAYS
81%	585750	3366250	30.4252823847	-98.1071028752	TRAVIS
81%	586250	3311750	29.9334791779	-98.1063465669	HAYS
81%	586750	3309750	29.9153967583	-98.1013286365	HAYS
81%	587250	3308250	29.9018259471	-98.0962717183	HAYS
81%	589750	3324250	30.0460212507	-98.0690344314	HAYS
81%	590750	3313750	29.9512018159	-98.0595565191	HAYS
81%	590750	3368250	30.4429614975	-98.0548706791	TRAVIS
81%	593750	3314250	29.9554879801	-98.0284272838	HAYS
81%	595750	3342250	30.2079813600	-98.0051776677	HAYS
81%	596250	3300250	29.8289669829	-98.0037791138	HAYS
81%	596250	3323250	30.0365035936	-98.0017094874	HAYS
81%	597250	3355750	30.3296704031	-97.9883467041	TRAVIS
81%	598250	3296250	29.7927154889	-97.9834462749	HAYS
81%	599250	3305250	29.8738459779	-97.9722701328	HAYS
81%	599750	3316750	29.9775728138	-97.9660212992	HAYS
81%	600250	3389250	30.6316771650	-97.9539158949	WILLIAMSON
81%	600750	3304750	29.8692124815	-97.9567867744	HAYS
81%	600750	3388750	30.6271239820	-97.9487480257	WILLIAMSON
81%	602250	3315250	29.9638321854	-97.9402543670	HAYS
81%	602750	3315250	29.9637904014	-97.9350729829	HAYS
81%	603750	3308750	29.9050560300	-97.9253407601	HAYS
81%	603750	3319250	29.9997983824	-97.9243213138	HAYS
81%	604250	3309250	29.9095252991	-97.9201137773	HAYS
81%	604250	3317250	29.9817099017	-97.9193335813	HAYS
81%	604250	3323250	30.0358478220	-97.9187465727	HAYS
81%	604750	3315750	29.9681327438	-97.9142985098	HAYS
81%	604750	3323250	30.0358050996	-97.9135614827	HAYS
81%	605250	3315750	29.9680899335	-97.9091169467	HAYS
81%	605250	3316250	29.9726014383	-97.9090676556	HAYS
81%	605250	3316750	29.9771129399	-97.9090183532	HAYS
81%	605250	3396750	30.6989122131	-97.9009844181	WILLIAMSON
81%	605750	3333250	30.1259474285	-97.9021953130	HAYS
81%	605750	3337750	30.1665497880	-97.9017456275	TRAVIS
81%	606750	3384750	30.5905146247	-97.8865650931	WILLIAMSON
81%	607250	3309250	29.9092672118	-97.8890427242	HAYS
81%	607250	3317750	29.9859625293	-97.8881898297	HAYS
81%	607250	3322250	30.0265655619	-97.8877369637	HAYS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
81%	607750	3308250	29.9002004630	-97.8839648457	HAYS
81%	608250	3398750	30.7166870985	-97.8694532031	WILLIAMSON
81%	608250	3409750	30.8159267519	-97.8682924814	WILLIAMSON
81%	608250	3412250	30.8384810010	-97.8680278771	WILLIAMSON
81%	608250	3412750	30.8429918411	-97.8679749204	WILLIAMSON
81%	608750	3346250	30.2429771623	-97.8697184118	TRAVIS
81%	609250	3384750	30.5902889261	-97.8604936256	WILLIAMSON
81%	609750	3321750	30.0218324630	-97.8618658523	HAYS
81%	609750	3322250	30.0263438583	-97.8618143150	HAYS
81%	609750	3322750	30.0308552504	-97.8617627660	HAYS
81%	609750	3384750	30.5902431598	-97.8552793676	WILLIAMSON
81%	610250	3317750	29.9856963061	-97.8570953450	HAYS
81%	610250	3391750	30.6533506754	-97.8493182558	WILLIAMSON
81%	610750	3397250	30.7029244422	-97.8435094890	WILLIAMSON
81%	610750	3414250	30.8562930902	-97.8416730032	WILLIAMSON
81%	611250	3414250	30.8562462067	-97.8364444445	WILLIAMSON
81%	611250	3414750	30.8607569844	-97.8363899722	WILLIAMSON
81%	611750	3316750	29.9765376567	-97.8416529859	HAYS
81%	611750	3323750	30.0396968881	-97.8409189073	HAYS
81%	611750	3414750	30.8607098814	-97.8311611812	WILLIAMSON
81%	612250	3322750	30.0306284004	-97.8358392362	HAYS
81%	612250	3325750	30.0576964402	-97.8355226507	HAYS
81%	612750	3315750	29.9674233294	-97.8313948727	HAYS
81%	612750	3317750	29.9854688468	-97.8311835964	HAYS
81%	612750	3324250	30.0441164270	-97.8304956227	HAYS
81%	612750	3351750	30.2922348470	-97.8275624311	TRAVIS
81%	613250	3323750	30.0395588901	-97.8253634880	HAYS
81%	613250	3324250	30.0440702150	-97.8253102600	HAYS
81%	613250	3380750	30.5538293567	-97.8192171976	WILLIAMSON
81%	614750	3308750	29.9040785855	-97.8114204734	CALDWELL
81%	614750	3381250	30.5581975579	-97.8035251987	WILLIAMSON
81%	615250	3376250	30.5130401493	-97.7988680272	WILLIAMSON
81%	617250	3326750	30.0662493982	-97.7835520782	HAYS
81%	618250	3320750	30.0120181136	-97.7738460747	HAYS
81%	618750	3409250	30.8104109673	-97.7585982653	WILLIAMSON
81%	619250	3354250	30.3141671867	-97.7597007764	TRAVIS
81%	619250	3380750	30.5532471623	-97.7566712500	WILLIAMSON
81%	619250	3409250	30.8103607964	-97.7533723526	WILLIAMSON
81%	619750	3380250	30.5486864404	-97.7515169091	WILLIAMSON
81%	620250	3322250	30.0253569554	-97.7529424593	HAYS
81%	620250	3347250	30.2509137213	-97.7501028769	TRAVIS
81%	620250	3411750	30.8328130585	-97.7426267197	WILLIAMSON
81%	621250	3288250	29.7184894775	-97.7464161687	CALDWELL
81%	621750	3410250	30.8191280317	-97.7271240240	WILLIAMSON
81%	622250	3362250	30.3860428665	-97.7275710032	TRAVIS
81%	623250	3291750	29.7498716708	-97.7253434666	CALDWELL
81%	623750	3328750	30.0836526852	-97.7158964922	TRAVIS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
81%	623750	3337250	30.1603411016	-97.7149037495	TRAVIS
81%	623750	3339750	30.1828963418	-97.7146110379	TRAVIS
81%	624250	3317750	29.9843568907	-97.7119935153	CALDWELL
81%	624250	3339750	30.1828453500	-97.7094186486	TRAVIS
81%	624250	3372750	30.4805663820	-97.7055079267	WILLIAMSON
81%	624750	3293750	29.7677666191	-97.7096024537	CALDWELL
81%	624750	3307750	29.8940822086	-97.7079780902	CALDWELL
81%	625250	3307250	29.8895201783	-97.7028591755	CALDWELL
81%	625750	3307250	29.8894691730	-97.6976820830	CALDWELL
81%	625750	3359750	30.3631286914	-97.6914498967	TRAVIS
81%	625750	3372250	30.4758995419	-97.6899440797	WILLIAMSON
81%	626250	3293250	29.7631030619	-97.6941485077	CALDWELL
81%	626250	3325750	30.0563302461	-97.6903171458	TRAVIS
81%	626250	3410250	30.8186573679	-97.6800876231	WILLIAMSON
81%	626750	3293750	29.7675631915	-97.6889191966	CALDWELL
81%	626750	3385750	30.5975842304	-97.6778795939	WILLIAMSON
81%	626750	3386250	30.6020949162	-97.6778183316	WILLIAMSON
81%	627750	3393750	30.6696481128	-97.6664614322	WILLIAMSON
81%	628250	3378250	30.5297640740	-97.6631648892	WILLIAMSON
81%	628250	3385250	30.5929136611	-97.6622987405	WILLIAMSON
81%	628250	3387250	30.6109562835	-97.6620507662	WILLIAMSON
81%	628750	3400750	30.7326886171	-97.6551495567	WILLIAMSON
81%	629750	3318250	29.9882980350	-97.6549311837	CALDWELL
81%	629750	3318750	29.9928090988	-97.6548703597	CALDWELL
81%	630250	3367250	30.4303130175	-97.6436991304	TRAVIS
81%	630250	3382750	30.5701444059	-97.6417572783	WILLIAMSON
81%	630250	3391750	30.6513353944	-97.6406234965	WILLIAMSON
81%	630750	3411750	30.8317009755	-97.6328606171	WILLIAMSON
81%	631250	3311750	29.9294945471	-97.6401834745	CALDWELL
81%	631250	3339250	30.1775989927	-97.6367887364	TRAVIS
81%	631250	3395250	30.6827996906	-97.6297437757	WILLIAMSON
81%	632250	3359750	30.3624341092	-97.6238271005	TRAVIS
81%	633250	3281250	29.6540998672	-97.6232398496	CALDWELL
81%	633250	3341250	30.1954249289	-97.6157687033	TRAVIS
81%	633750	3371250	30.4660145564	-97.6067491149	TRAVIS
81%	634250	3369750	30.4524269076	-97.6017352945	TRAVIS
81%	634750	3342250	30.2042811706	-97.6000625673	TRAVIS
81%	637750	3298250	29.8069860085	-97.5745899658	CALDWELL
81%	638250	3392250	30.6549459274	-97.5570847826	WILLIAMSON
81%	638250	3393750	30.6684771645	-97.5568837042	WILLIAMSON
81%	638750	3297250	29.7978519724	-97.5643737185	CALDWELL
81%	639250	3323750	30.0368747995	-97.5557547203	BASTROP
81%	640750	3391750	30.6501433072	-97.5310676498	WILLIAMSON
81%	641250	3324250	30.0411562537	-97.5349507761	BASTROP
81%	641250	3350250	30.2757133030	-97.5314784965	TRAVIS
81%	641750	3284750	29.6847362390	-97.5349820061	CALDWELL
81%	641750	3319750	30.0005011908	-97.5303651254	BASTROP

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
81%	642250	3370750	30.4605284549	-97.5182984942	TRAVIS
81%	642750	3319250	29.9958742575	-97.5200671536	BASTROP
81%	642750	3334750	30.1357074241	-97.5179848860	BASTROP
81%	643250	3334750	30.1356487323	-97.5127954014	BASTROP
81%	643750	3284750	29.6845060910	-97.5143173047	CALDWELL
81%	643750	3386750	30.6046825513	-97.5004629205	WILLIAMSON
81%	644250	3340250	30.1851478556	-97.5016662940	BASTROP
81%	644750	3339250	30.1760671867	-97.4966112672	BASTROP
81%	644750	3339750	30.1805778105	-97.4965427706	BASTROP
81%	645250	3339750	30.1805181912	-97.4913509868	BASTROP
81%	645250	3379250	30.5368463359	-97.4858716396	WILLIAMSON
81%	645250	3379750	30.5413566882	-97.4858016517	WILLIAMSON
81%	645750	3379250	30.5367856564	-97.4806610328	WILLIAMSON
81%	645750	3379750	30.5412959979	-97.4805908042	WILLIAMSON
81%	646250	3310250	29.9142678954	-97.4850238789	CALDWELL
81%	646250	3379250	30.5367247687	-97.4754504418	WILLIAMSON
81%	646250	3379750	30.5412350992	-97.4753799726	WILLIAMSON
81%	646250	3388250	30.6179102178	-97.4741795592	WILLIAMSON
81%	646750	3379750	30.5411739922	-97.4701691569	WILLIAMSON
81%	646750	3380250	30.5456843086	-97.4700984312	WILLIAMSON
81%	647250	3377750	30.5230714226	-97.4652420626	WILLIAMSON
81%	647250	3378250	30.5275817411	-97.4651711603	WILLIAMSON
81%	647250	3379250	30.5366023683	-97.4650293076	WILLIAMSON
81%	647250	3379750	30.5411126769	-97.4649583572	WILLIAMSON
81%	647750	3378750	30.5320305547	-97.4598899394	WILLIAMSON
81%	647750	3379250	30.5365408556	-97.4598187645	WILLIAMSON
81%	647750	3379750	30.5410511533	-97.4597475735	WILLIAMSON
81%	648250	3308750	29.9004960633	-97.4645200377	CALDWELL
81%	648250	3379750	30.5409894213	-97.4545368059	WILLIAMSON
81%	648750	3403750	30.7574168453	-97.4458666921	WILLIAMSON
81%	649750	3329250	30.0852508856	-97.4461103281	BASTROP
81%	650250	3313750	29.9453602093	-97.4431097248	BASTROP
81%	650250	3364250	30.4009213822	-97.4359305240	TRAVIS
81%	652250	3331750	30.1074942284	-97.4198183750	BASTROP
81%	652750	3389250	30.6261173591	-97.4062391256	WILLIAMSON
81%	653250	3343250	30.2111093155	-97.4077765447	BASTROP
81%	653250	3346750	30.2426821167	-97.4072676833	BASTROP
81%	653250	3347250	30.2471925038	-97.4071949230	BASTROP
81%	654250	3331250	30.1027324589	-97.3991401124	BASTROP
81%	654250	3341750	30.1974515490	-97.3976094831	BASTROP
81%	654750	3331750	30.1071795865	-97.3938796852	BASTROP
81%	654750	3361250	30.3732905937	-97.3895458189	BASTROP
81%	655250	3331250	30.1026056014	-97.3887651896	BASTROP
81%	655250	3361750	30.3777366190	-97.3842699532	BASTROP
81%	656250	3334750	30.1340507932	-97.3778743364	BASTROP
81%	656250	3338250	30.1656235013	-97.3773575209	BASTROP
81%	656250	3338750	30.1701338751	-97.3772836232	BASTROP

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
81%	656750	3370750	30.4587259253	-97.3673130497	WILLIAMSON
81%	658750	3378750	30.5306248342	-97.3452674468	WILLIAMSON
81%	659750	3344750	30.2238025791	-97.3400394566	BASTROP
81%	660250	3385750	30.5935652271	-97.3285555237	WILLIAMSON
81%	660750	3385750	30.5934981438	-97.3233422852	WILLIAMSON
81%	661750	3385250	30.5888534166	-97.3129939990	WILLIAMSON
81%	662750	3324750	30.0429943148	-97.3119512374	BASTROP
81%	663250	3324750	30.0429276655	-97.3067671107	BASTROP
81%	663250	3379250	30.5345306622	-97.2983001726	WILLIAMSON
81%	663750	3324750	30.0428608120	-97.3015830014	BASTROP
81%	664250	3359250	30.3539948503	-97.2910307489	BASTROP
81%	665750	3390250	30.6334042135	-97.2704894508	WILLIAMSON
81%	667750	3369750	30.4482222366	-97.2529427848	WILLIAMSON
81%	668750	3370250	30.4525922684	-97.2424512962	WILLIAMSON
81%	670250	3307250	29.8841167238	-97.2369803910	BASTROP
81%	670250	3389750	30.6282615792	-97.2236355752	WILLIAMSON
81%	671750	3306750	29.8793980964	-97.2215334627	BASTROP
81%	672750	3325250	30.0461325985	-97.2081908781	BASTROP
81%	674750	3317250	29.9736878466	-97.1887668023	BASTROP
81%	675250	3354250	30.3073509693	-97.1774619141	BASTROP
81%	676750	3334750	30.1312494844	-97.1651375173	BASTROP
81%	677250	3334250	30.1266669758	-97.1600328573	BASTROP
81%	677750	3328750	30.0769853860	-97.1557663990	BASTROP
81%	680750	3323250	30.0269367504	-97.1255887276	BASTROP
81%	682250	3345750	30.2296529459	-97.1061697394	BASTROP
81%	683250	3327750	30.0671529520	-97.0988998827	BASTROP
81%	683250	3346250	30.2340120298	-97.0956962104	BASTROP
81%	683750	3346750	30.2384460552	-97.0904155126	BASTROP
81%	684250	3330250	30.0895512021	-97.0880966360	BASTROP
81%	684250	3344250	30.2158221284	-97.0856587576	BASTROP
81%	685250	3325250	30.0443027260	-97.0785964550	BASTROP
81%	685250	3326250	30.0533221763	-97.0784222879	BASTROP
81%	685750	3323750	30.0306977183	-97.0736747353	BASTROP
81%	685750	3326750	30.0577560068	-97.0731509450	BASTROP
81%	686750	3323250	30.0260357927	-97.0633968473	BASTROP
77%	574250	3329750	30.0966912827	-98.2294161045	HAYS
77%	578250	3351750	30.2949567435	-98.1862756920	HAYS
77%	578750	3327250	30.0738501770	-98.1829033898	HAYS
77%	578750	3327750	30.0783619696	-98.1828663112	HAYS
77%	579250	3343250	30.2181934458	-98.1765176686	HAYS
77%	579750	3343250	30.2181607049	-98.1713226505	HAYS
77%	580750	3351750	30.2947925373	-98.1602804161	HAYS
77%	581750	3338250	30.1729109473	-98.1509298888	HAYS
77%	581750	3357250	30.3443528640	-98.1494537588	TRAVIS
77%	582750	3310750	29.9246963228	-98.1426846514	HAYS
77%	582750	3335750	30.1502848981	-98.1407403300	HAYS
77%	584250	3328750	30.0870182645	-98.1257226715	HAYS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
77%	584250	3337250	30.1637170225	-98.1250466446	HAYS
77%	584250	3342750	30.2133451451	-98.1246078258	HAYS
77%	584750	3311750	29.9335836155	-98.1218868278	HAYS
77%	584750	3324750	30.0508898487	-98.1208537039	HAYS
77%	584750	3365250	30.4163302272	-98.1175958253	TRAVIS
77%	586250	3309250	29.9109201381	-98.1065480493	HAYS
77%	586750	3311250	29.9289321630	-98.1012070466	HAYS
77%	587250	3311250	29.9288967464	-98.0960272206	HAYS
77%	587750	3357750	30.3484434137	-98.0869928911	TRAVIS
77%	591250	3312750	29.9421412876	-98.0544609696	HAYS
77%	591250	3341250	30.1993046829	-98.0520127039	HAYS
77%	591250	3366750	30.4293895378	-98.0497951954	TRAVIS
77%	593250	3361250	30.3796111445	-98.0294622526	TRAVIS
77%	594250	3308250	29.9013093126	-98.0237747577	HAYS
77%	594750	3357750	30.3479145687	-98.0141691298	TRAVIS
77%	595250	3360250	30.3704321451	-98.0087400668	TRAVIS
77%	596750	3320750	30.0139061720	-97.9967514068	HAYS
77%	597250	3400750	30.7356810264	-97.9841302553	WILLIAMSON
77%	599250	3303750	29.8603109741	-97.9724088552	HAYS
77%	599250	3404250	30.7670931309	-97.9629028217	WILLIAMSON
77%	600250	3401750	30.7444540294	-97.9526991245	WILLIAMSON
77%	600750	3321750	30.0226065617	-97.9551844838	HAYS
77%	601750	3330750	30.1037306991	-97.9439538172	HAYS
77%	602250	3398250	30.7127066113	-97.9321565683	WILLIAMSON
77%	602250	3403250	30.7578167168	-97.9316589792	WILLIAMSON
77%	602750	3308750	29.9051400112	-97.9356974222	HAYS
77%	602750	3331250	30.1081583144	-97.9335280326	HAYS
77%	602750	3404750	30.7713065367	-97.9262853630	WILLIAMSON
77%	603250	3309750	29.9141212787	-97.9304226714	HAYS
77%	603750	3398250	30.7125768339	-97.9164937277	WILLIAMSON
77%	604250	3317750	29.9862214125	-97.9192847249	HAYS
77%	604750	3316250	29.9726442564	-97.9142494526	HAYS
77%	604750	3316750	29.9771557658	-97.9142003843	HAYS
77%	604750	3382750	30.5726471005	-97.9076248173	WILLIAMSON
77%	604750	3397750	30.7079782767	-97.9061028024	WILLIAMSON
77%	605250	3315250	29.9635784255	-97.9091662267	HAYS
77%	605750	3400250	30.7304447215	-97.8954043950	WILLIAMSON
77%	606250	3318750	29.9950725892	-97.8984551297	HAYS
77%	606750	3320250	30.0085634978	-97.8931219776	HAYS
77%	606750	3414750	30.8611714120	-97.8834496374	WILLIAMSON
77%	607250	3413750	30.8521045189	-97.8783257562	WILLIAMSON
77%	607250	3414250	30.8566153655	-97.8782732529	WILLIAMSON
77%	607750	3337750	30.1663743046	-97.8809781462	TRAVIS
77%	607750	3392750	30.6626009905	-97.8753020633	WILLIAMSON
77%	608250	3405250	30.7753289004	-97.8687680183	WILLIAMSON
77%	608750	3320250	30.0083874876	-97.8723875424	HAYS
77%	610250	3312750	29.9405820059	-97.8576114813	HAYS

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
77%	611250	3311250	29.9269574944	-97.8474074385	HAYS
77%	611250	3313250	29.9450032252	-97.8471993962	HAYS
77%	611250	3321250	30.0171856408	-97.8463653362	HAYS
77%	611250	3392250	30.6577687896	-97.8388291082	WILLIAMSON
77%	612750	3389750	30.6350734599	-97.8234487558	WILLIAMSON
77%	613750	3323250	30.0350011624	-97.8202318229	HAYS
77%	613750	3325250	30.0530464221	-97.8200179476	HAYS
77%	615250	3327750	30.0754622720	-97.8041894161	HAYS
77%	615250	3391250	30.6483673986	-97.7971984674	WILLIAMSON
77%	615750	3321750	30.0212796450	-97.7996555159	HAYS
77%	616250	3305750	29.8768693937	-97.7962116711	CALDWELL
77%	616750	3390250	30.6391999422	-97.7816598547	WILLIAMSON
77%	617250	3327250	30.0707606358	-97.7834968967	HAYS
77%	618250	3409750	30.8149716170	-97.7637664242	WILLIAMSON
77%	618750	3409750	30.8149216479	-97.7585402545	WILLIAMSON
77%	619250	3409750	30.8148714680	-97.7533140978	WILLIAMSON
77%	619750	3370750	30.4629796723	-97.7526114615	WILLIAMSON
77%	619750	3409750	30.8148210775	-97.7480879542	WILLIAMSON
77%	620250	3409750	30.8147704763	-97.7428618239	WILLIAMSON
77%	620750	3403750	30.7605917148	-97.7383426735	WILLIAMSON
77%	621250	3292250	29.7545806868	-97.7459672229	CALDWELL
77%	621750	3351250	30.2868521641	-97.7340517886	TRAVIS
77%	622250	3328250	30.0792926873	-97.7315157436	TRAVIS
77%	622250	3351250	30.2868017859	-97.7288538936	TRAVIS
77%	622750	3335250	30.1423980545	-97.7255182466	TRAVIS
77%	622750	3363750	30.3995248083	-97.7221917273	TRAVIS
77%	623250	3379250	30.5393099807	-97.7151532176	WILLIAMSON
77%	623750	3374750	30.4986612670	-97.7104781053	WILLIAMSON
77%	624250	3317250	29.9798457173	-97.7120517370	CALDWELL
77%	624250	3323250	30.0339795865	-97.7113522046	TRAVIS
77%	624250	3329750	30.0926240917	-97.7105922266	TRAVIS
77%	624250	3335750	30.1467570006	-97.7098887181	TRAVIS
77%	624750	3319750	30.0023507233	-97.7065775361	CALDWELL
77%	625750	3307750	29.8939803826	-97.6976234259	CALDWELL
77%	626750	3307750	29.8938777442	-97.6872688149	CALDWELL
77%	626750	3358250	30.3494915276	-97.6812277950	TRAVIS
77%	627250	3385250	30.5930204568	-97.6727267945	WILLIAMSON
77%	627750	3338750	30.1734607173	-97.6731932062	TRAVIS
77%	627750	3385250	30.5929671633	-97.6675127606	WILLIAMSON
77%	628750	3411750	30.8319199685	-97.6537679718	WILLIAMSON
77%	629250	3360750	30.3717806404	-97.6549138356	TRAVIS
77%	629750	3366750	30.4258562544	-97.6489666159	TRAVIS
77%	629750	3385250	30.5927519013	-97.6466567646	WILLIAMSON
77%	630750	3310250	29.9160145949	-97.6455457687	CALDWELL
77%	630750	3409250	30.8091487289	-97.6331800978	WILLIAMSON
77%	631750	3309750	29.9113967186	-97.6352506218	CALDWELL
77%	631750	3311750	29.9294410181	-97.6350044464	CALDWELL

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
77%	631750	3340750	30.1910775897	-97.6314096922	TRAVIS
77%	631750	3379250	30.5384059352	-97.6265638211	WILLIAMSON
77%	631750	3379750	30.5429165667	-97.6265003312	WILLIAMSON
77%	631750	3382750	30.5699802872	-97.6261190905	WILLIAMSON
77%	631750	3383250	30.5744908959	-97.6260555002	WILLIAMSON
77%	631750	3392250	30.6556812971	-97.6249084156	WILLIAMSON
77%	632250	3382250	30.5654145616	-97.6209702070	WILLIAMSON
77%	632750	3412750	30.8404994065	-97.6118236455	WILLIAMSON
77%	633250	3315750	29.9653674215	-97.6189688173	CALDWELL
77%	633750	3314750	29.9562909866	-97.6139131862	CALDWELL
77%	633750	3315250	29.9608019951	-97.6138505884	CALDWELL
77%	633750	3315750	29.9653130003	-97.6137879764	CALDWELL
77%	633750	3316250	29.9698240023	-97.6137253502	CALDWELL
77%	633750	3342750	30.2089025081	-97.6103857607	TRAVIS
77%	633750	3363250	30.3938438152	-97.6077746654	TRAVIS
77%	634250	3314250	29.9517253797	-97.6087956443	CALDWELL
77%	634250	3314750	29.9562363815	-97.6087328271	CALDWELL
77%	634250	3316750	29.9742803565	-97.6084814153	CALDWELL
77%	634250	3341750	30.1998257017	-97.6053194537	TRAVIS
77%	634250	3342750	30.2088473479	-97.6051922286	TRAVIS
77%	634750	3286750	29.7035610922	-97.6070613828	CALDWELL
77%	634750	3359750	30.3621576510	-97.5978189692	TRAVIS
77%	635250	3285250	29.6899731430	-97.6020814705	CALDWELL
77%	635250	3285750	29.6944843107	-97.6020190141	CALDWELL
77%	635250	3286250	29.6989954752	-97.6019565435	CALDWELL
77%	636250	3378750	30.5333923993	-97.5797308543	WILLIAMSON
77%	636750	3345250	30.2311222704	-97.5789005489	TRAVIS
77%	637750	3392250	30.6550037501	-97.5623018959	WILLIAMSON
77%	637750	3392750	30.6595141761	-97.5622351270	WILLIAMSON
77%	637750	3393750	30.6685350183	-97.5621015439	WILLIAMSON
77%	638250	3385250	30.5917997656	-97.5580213506	WILLIAMSON
77%	638250	3391250	30.6459250863	-97.5572187593	WILLIAMSON
77%	638250	3391750	30.6504355085	-97.5571517785	WILLIAMSON
77%	638750	3375750	30.5060426904	-97.5540785410	WILLIAMSON
77%	638750	3391250	30.6458670749	-97.5520021451	WILLIAMSON
77%	639750	3323750	30.0368177698	-97.5505703055	BASTROP
77%	640250	3323750	30.0367605359	-97.5453859056	BASTROP
77%	640750	3319750	30.0006165127	-97.5407300992	BASTROP
77%	640750	3339250	30.1765366625	-97.5381442007	TRAVIS
77%	641750	3351250	30.2846761299	-97.5261467873	TRAVIS
77%	642250	3324750	30.0455511096	-97.5245147530	BASTROP
77%	642750	3330250	30.0951110185	-97.5185909234	BASTROP
77%	642750	3333750	30.1266860233	-97.5181196678	BASTROP
77%	643250	3319250	29.9958158935	-97.5148849538	BASTROP
77%	643250	3333750	30.1266273526	-97.5129306547	BASTROP
77%	643250	3334250	30.1311380441	-97.5128630357	BASTROP
77%	643750	3324250	30.0408649265	-97.5090279796	BASTROP

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
77%	643750	3333250	30.1220577930	-97.5078094963	BASTROP
77%	643750	3334750	30.1355898354	-97.5076059321	BASTROP
77%	643750	3359750	30.3611195758	-97.5041927575	TRAVIS
77%	644250	3306250	29.8784175564	-97.5062739759	CALDWELL
77%	644250	3339250	30.1761265899	-97.5018028302	BASTROP
77%	644250	3381250	30.5550085460	-97.4960147799	WILLIAMSON
77%	644250	3386250	30.6001120073	-97.4953183779	WILLIAMSON
77%	644750	3380250	30.5459275301	-97.4909427520	WILLIAMSON
77%	644750	3381750	30.5594585901	-97.4907333683	WILLIAMSON
77%	645250	3381750	30.5593980648	-97.4855215420	WILLIAMSON
77%	645750	3310750	29.9188380787	-97.4901337121	CALDWELL
77%	645750	3330250	30.0947563690	-97.4874669675	BASTROP
77%	646750	3293750	29.7653511282	-97.4820989320	CALDWELL
77%	646750	3294250	29.7698620032	-97.4820309090	CALDWELL
77%	647250	3298750	29.8104001819	-97.4762454847	CALDWELL
77%	647750	3294750	29.7742537444	-97.4716215524	CALDWELL
77%	647750	3322250	30.0223455261	-97.4678299104	BASTROP
77%	648250	3395750	30.6853168607	-97.4522424583	WILLIAMSON
77%	650250	3364750	30.4054317225	-97.4358586190	TRAVIS
77%	650250	3379750	30.5407404101	-97.4336938973	WILLIAMSON
77%	650250	3387250	30.6083936470	-97.4326060230	WILLIAMSON
77%	650750	3346250	30.2384849300	-97.4333136138	BASTROP
77%	650750	3349250	30.2655475617	-97.4328840182	BASTROP
77%	650750	3349750	30.2700579888	-97.4328123622	BASTROP
77%	650750	3370250	30.4549826900	-97.4298604668	WILLIAMSON
77%	650750	3378250	30.5271469342	-97.4287010656	WILLIAMSON
77%	651750	3376750	30.5134901656	-97.4185003346	WILLIAMSON
77%	652250	3349250	30.2653600545	-97.4172957883	BASTROP
77%	652250	3389250	30.6261811823	-97.4114543274	WILLIAMSON
77%	652250	3389750	30.6306913135	-97.4113806390	WILLIAMSON
77%	652750	3290250	29.7330491972	-97.4205526759	CALDWELL
77%	652750	3290750	29.7375599626	-97.4204819879	CALDWELL
77%	652750	3291250	29.7420707249	-97.4204112838	CALDWELL
77%	652750	3291750	29.7465814838	-97.4203405636	CALDWELL
77%	652750	3292250	29.7510922396	-97.4202698274	CALDWELL
77%	652750	3349250	30.2652971401	-97.4120997444	BASTROP
77%	652750	3349750	30.2698075222	-97.4120271390	BASTROP
77%	652750	3389750	30.6306274788	-97.4061651955	WILLIAMSON
77%	653250	3291250	29.7420089150	-97.4152424261	CALDWELL
77%	653250	3343750	30.2156197255	-97.4077038996	BASTROP
77%	653250	3365750	30.4140745275	-97.4044911848	TRAVIS
77%	653250	3390250	30.6350735401	-97.4008755803	WILLIAMSON
77%	653750	3389750	30.6304991823	-97.3957343586	WILLIAMSON
77%	653750	3390250	30.6350092758	-97.3956599285	WILLIAMSON
77%	654750	3292750	29.7553544065	-97.3995209663	CALDWELL
77%	654750	3293250	29.7598651106	-97.3994492725	CALDWELL
77%	655250	3292250	29.7507810595	-97.3944233884	CALDWELL

Irr. Value	WGS84 UTM 14N X-Coord.	WGS84 UTM 14N Y-Coord.	WGS84 Lattitude	WGS84 Longitude	County
77%	656250	3356250	30.3279948976	-97.3746866354	BASTROP
77%	657250	3340250	30.1835360640	-97.3666785495	BASTROP
77%	657250	3340750	30.1880464015	-97.3666041121	BASTROP
77%	657250	3370750	30.4586606545	-97.3621069025	WILLIAMSON
77%	658250	3343250	30.2104681653	-97.3558456218	BASTROP
77%	660250	3385250	30.5890552564	-97.3286329385	WILLIAMSON
77%	663250	3298250	29.8038772677	-97.3108091224	BASTROP
77%	666750	3390750	30.6377748018	-97.2599783062	WILLIAMSON
77%	667250	3367750	30.4302521998	-97.2584688116	WILLIAMSON
77%	667250	3394750	30.6737828905	-97.2541144388	WILLIAMSON
77%	669750	3321250	30.0104715964	-97.2399330383	BASTROP
77%	670250	3353250	30.2990449541	-97.2296011450	BASTROP
77%	670250	3382750	30.5651255160	-97.2247872941	WILLIAMSON
77%	670750	3354250	30.3079943661	-97.2242412195	BASTROP
77%	670750	3382750	30.5650543353	-97.2195758624	WILLIAMSON
77%	670750	3383250	30.5695640630	-97.2194934766	WILLIAMSON
77%	671250	3357750	30.3394929623	-97.2184720732	BASTROP
77%	671750	3315750	29.9605812756	-97.2200895160	BASTROP
77%	677250	3316750	29.9688190385	-97.1629490771	BASTROP
77%	677250	3318250	29.9823490203	-97.1627000212	BASTROP
77%	677250	3330250	30.0905878043	-97.1607014629	BASTROP
77%	677250	3334750	30.1311768573	-97.1599491963	BASTROP
77%	677750	3317250	29.9732566629	-97.1576859886	BASTROP
77%	677750	3333750	30.1220842852	-97.1549286684	BASTROP
77%	678750	3331750	30.1038986451	-97.1448902667	BASTROP
77%	680250	3346250	30.2344613262	-97.1268576349	BASTROP
77%	680750	3345250	30.2253675295	-97.1218355066	BASTROP
77%	684750	3325750	30.0488881109	-97.0836931615	BASTROP
77%	685250	3327250	30.0623416133	-97.0782480417	BASTROP
77%	685750	3324750	30.0397171611	-97.0735002176	BASTROP
77%	686250	3323750	30.0306217070	-97.0684919325	BASTROP
77%	686250	3328750	30.0757186505	-97.0676162064	BASTROP
77%	686250	3330250	30.0892476687	-97.0673531014	BASTROP

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